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Electric Vehicle Conductive Charging Systems

Part 23 d.c. Electric Vehicle Supply Equipment

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FOREWORD

This Indian Standard was adopted by the Bureau of Indian Standards, after the draft finalized by the Electrotechnology in Mobility Sectional Committee had been approved by the Electrotechnical Division Council.

This standard provides guidance to Industry for setting up charging stations and to the electric vehicle manufactures to prepare the vehicles to charge the batteries, from these charging stations.

Considerable assistance has been obtained from IEC 61851-23 Edition 2 CDV while preparing this standard. This standard corresponds to the requirements of IEC 61851-23 Edition 2 CDV in the requirements it contains, but certain modifications have been done in relation to the crossreferred standards, including content, and ambient conditions.

The cross references of IEC have been modified to refer Indian Standards whenever available. Where corresponding Indian Standards are not available, the IEC references have been retained. The committee has decided that these IEC standards are suitable to be used till equivalent/corresponding Indian Standards are published.

The committee had agreed to inclusion of System A and System C defined in IEC standards, and as such the references to other types and systems have not been retained in this edition. The ambient temperature has been modified, and system voltages have been aligned as per IS 12360.

This standard is to be read in conjunction with IEC 17017-1 : 2018.

The composition of the committee responsible for formulation of this standard is given at Annex G.

For the purpose of deciding whether a particular requirement of this temporary standard is complied with, the final value, observed or calculated expressing the result of a test, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding of numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

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Indian Standard

ELECTRIC VEHICLE CONDUCTIVE CHARGING SYSTEM

Part 23 d.c. Electric Vehicle Supply Equipment

1 SCOPE

This standard applies to the d.c. electric vehicle supply equipment for charging electric road vehicles, with a rated supply voltage up to 1 000 V a.c. or up to 1 500 V d.c. and a rated output voltage up to 1 500 V d.c.

This standard specifies the d.c. electric vehicle supply equipment of systems A and C as defined in Annex A and Annex B. Requirements for systems that do not comply with Systems A or C are not covered by this standard.

This standard also provides the requirements for bi-directional power flow for System A as specified in Annex A, with reverse power flow with voltage up to 1 000 V a.c. or 1 500 V d.c.

Requirements for non-isolated system are under consideration, and are not specified in this standard.

The requirements for digital communication between d.c. electric vehicle supply equipment and electric vehicle for control of d.c. charging are defined in IS 17017 (Part 24) : 2021.

Non-regulated d.c. electric vehicle supply equipment is not covered by this standard.

NOTES

- 1 The reverse output voltage up to 1 500 V d.c. is under consideration.
- 2 The requirements for bi-directional power flow for System C are under consideration. Annex C also provides information about bi-directional power flow.
- 3 This document includes information on electric vehicle fo conductive connection, but limited to the necessary content for describing the power and signalling interface.
- 4 Typical diagrams and variation of d.c. charging systems are shown in Annex D.

2 REFERENCES

This clause of IS 17017 (Part 1) is applicable except as follows:

Addition:

<i>Other Publication</i>	<i>Title</i>
IEC Guide 115	Applicaton of uncertainty of measurment to conformity assessment activities in the electrotechnical sector.
IS 732 : 2019	Code of practice for electrical wiring installations.
IS 10810 (Part 11)	Methods of test for cables: Part 11 Thermal ageing in air.
IS 12360 : 1988	Voltage bands for electrical installations including preferred voltages and frequency.
IS 12640 (Part 1) : 2016	Residual current operated circuit-breakers without integral overcurrent protection for household and similar users (RCCBs) : Part 1 General rules.
IS 12640 (Part 2) : 2016	Residual current operated circuit-breakers with integral overcurrent protection for household and similar users (RCBOs) : Part 1 General rules.
IS 13947 (Part 1) : 1993	Low-voltage switchgear and controlgear assemblies: Part 1 General rules.
IS/ISO 15118-2 : 2014	Road vehicles — Vehicle-to-grid communication interface: Part 2 Network and application protocol requirements.
IS/ISO 15118-3 : 2015	Road vehicles — Vehicle-to-grid communication interface: Part 3 Physical and ata link layer requirements.

IS 17017 (Part 23) : 2021

<i>Other Publication</i>	<i>Title</i>	<i>Other Publication</i>	<i>Title</i>
IS/ISO 15118-8 : 2018	Road vehicles — Vehicle-to-grid communication interface: Part 3 Physical and data link layer requirements for wireless communication	IEC 60695-10-3 : 2016	Fire hazard testing: Part 10 Abnormal heat: Section 3 Mould stress relief distortion test.
IS 15382 (Part 1) : 2014	Insulation coordination for equipment with low-voltage systems: Part 1 Principles, requirements and tests.	IS/IEC 60695-11-10 : 2013	Fire hazard testing: Part 11 Test flames: Section 10 50 W horizontal and vertical flame test methods.
IS 16463 (all parts)	Low-voltage surge protective devices.	IS/IEC 60947-2 : 2016	Low-voltage switchgear and controlgear : Part 2 Circuit breakers.
IS 17017 (Part 1) : 2018	Electric vehicle conductive charging system: Part 1 General requirements	IS/IEC 60990 : 2016	Methods of measurement of touch current and protective conductor current.
IS 17017 (Part 2/Sec 1) : 2020	Electric vehicle conductive charging system: Part 2 Plugs, socket-outlets, vehicle connectors and vehicle inlets: Section 1 General requirements.	IS/IEC 62305-4 : 2010	Protection against lightning — Part 4: Electrical and electronic systems within structures
IS 17017 (Part 2/Sec 3) : 2020	Electric vehicle conductive charging system: Part 2 Plugs, socket-outlets, vehicle connectors and vehicle inlets: Section 3 Dimensional compatibility and interchangeability requirements for d.c and a.c/d.c pin and contact-tube vehicle couplers,	IS/IEC 62368-1 : 2014	Audio, video and communication technology equipment — Part 1: Safety requirements
IS 17017 (Part 21/Sec 2) : 2019	Electric vehicle conductive charging system: Part 21 Electromagnetic compatibility (EMC) requirements: Section 2 Off-board chargers.	IEC 60245-1	Rubber insulated cables - Rated voltages up to and including 450/750 V: Part 1 General requirements
IS 17017 (Part 24) : 2021	Electric vehicle conductive charging system: Part 24 Digital communication between a d.c. electric vehicle supply equipment and an electric vehicle for control of d.c. charging.	IEC 60227-1	Polyvinyl chloride insulated cables of rated voltages up to and including 450/750 V: Part 1 General requirements
IS/ISO/IEC 17025 : 2017	General requirements for the competence of testing and calibration laboratories.	IEC 61439-7 : 2018	Low-voltage switchgear and controlgear assemblies: Part 7 Assemblies for specific applications such as marinas, camping sites, market squares, electric vehicle charging stations.
IS 17050 : 2018	Degrees of protection provided by enclosures for electrical equipment against external mechanical impacts (IK code)	IEC 61540 : 1998	Electrical accessories — Portable residual current devices without integral overcurrent protection for household and similar uses.
IS/IEC 60479-1 : 2005	Effects of current on human beings and livestock: Part 1 General aspects.	IEC 61557-8	Electrical safety in low voltage distribution systems up to 1 000 V a.c. and 1 500 V d.c. — Equipment for testing, measuring or monitoring of protective measures: Part 8 Insulation monitoring devices for IT systems.
IS/IEC 60479-2 : 2007	Effects of current on human beings and livestock: Part 2 Special aspects.	IEC 62477-1 : 2016	Safety requirements for power electronic converter systems and equipment: Part 1 General
		IEC 62909-1 : 2017	Bi-directional grid connected power converters: Part 1 General requirements.

<i>Other Publication</i>	<i>Title</i>
ISO 11898-1 : 2015	Road vehicles – Controller area network (CAN): Part 1 Data link layer and physical signalling
ISO/QC 302400 : 1994	Fixed capacitors for use in electronic equipment sectional specification for fixed capacitors for electromagnetic interference suppression and connection to the supply mains.
DIN SPEC 70121	Electromobility — Digital communication between a DC EV supply equipment and an electric vehicle for control of DC charging in the Combined Charging System

3 TERMINOLOGY

This clause of IS 17017 (Part 1) is applicable except as follows:

Addition:

The definitions included in this part are those having general application herein. Definitions applying to isolating transformers, safety isolating transformers, switch mode power supplies, and their construction are included in IEC 61558-1.

3.1 Electric Supply Equipment

3.1.101 *d.c. EV Charging System*

A system composed of a d.c. charger, cable assembly and the equipment on electric vehicle that is required to fulfil the charging function including digital communication for charging control.

3.1.102 *Isolated d.c. EV Supply Equipment*

d.c. electric vehicle supply equipment where the d.c. output circuit is separated by at least basic insulation from other circuits.

NOTE — See 8 for the requirements of separation between each circuit.

3.1.103 *Non-Isolated d.c. EV Supply Equipment*

d.c. electric vehicle supply equipment where the d.c. output circuit is not separated by protective separation from the a.c. supply network.

3.1.104 *Regulated d.c. EV Supply Equipment*

d.c. electric vehicle supply equipment that supplies vehicle battery with a charging current or charging voltage in accordance with the request from vehicle.

3.1.105 *Non-Regulated d.c. EV Supply Equipment*

Under consideration

3.1.106 *Plug and Cable d.c. EV Supply Equipment*

d.c. electric vehicle supply equipment which is intended to be connected to the a.c. supply network using a cable and plug according to IS/IEC 60309-1 and IS/IEC 60309-2 for industrial type, IS 1293 for domestic type, relevant national standards, or other standard plugs and socket outlets.

3.1.107 *d.c. EV Discharging Equipment*

Equipment specifically designed for electric vehicle discharging, for example a portable Vehicle-to-Load (V2L) power supply.

3.1.108 *Charging/Discharging Station*

A system composed of an EVPS and cable assembly that is required to fulfil the charging and discharging functions including digital communication for charging and discharging control.

3.1.109 *Electric Vehicle Power System (EVPS)*

Equipment or a combination of equipment providing dedicated functions to provide a.c. or d.c. reverse power to socket-outlets or a bi-directional grid-connected power converter according to IEC 62909-1 from an electric vehicle. It can provide dedicated functions to supply electric energy from a fixed electrical installation or a.c. supply network to an electric vehicle for the purpose of charging.

3.1.110 *Charging State*

A physical status of d.c. electric vehicle charging system.

3.1.111 *Discharging Mode*

Method necessary to condition energy of the rechargeable energy storage systems (RESS) to a regulated voltage/current level to external electrical circuit.

3.1.112 *Maximum Current Control (MCC)*

Control mode where a d.c. electric vehicle charging/discharging supply equipment regulates charging/discharging current according to the maximum current value communicated by the vehicle.

3.1.113 *Controlled Current Charging (CCC)*

Energy transfer method where the d.c. electric vehicle supply equipment regulates charging current according to the current value requested by the vehicle.

3.1.114 *Controlled Voltage Charging (CVC)*

Energy transfer method where the d.c. electric vehicle supply equipment regulates charging voltage according to the voltage value requested by the vehicle.

3.1.115 Constant Current Control Mode (CCCM)

A control mode of electric vehicle supply equipment that regulates the output current as constant during the control process according to the target-current value requested by the vehicle or the other sources such as thermal management unit of electric vehicle supply equipment.

3.1.116 Constant Voltage Control Mode (CVCM)

A control mode of electric vehicle supply equipment that regulates the output voltage as constant during the control process according to the target-voltage value requested by the vehicle.

3.1.117 Constant Power Control Mode (CPCM)

A control mode of electric vehicle supply equipment that regulates the output power as constant during the control process according to the target-power value requested by the vehicle or the other sources such as the demand management of the grid.

3.1.118 Electric Vehicle Supply Equipment (EVSE)

conductors, including the phase(s), neutral and protective earth conductors, the electric vehicle couplers, attached plugs, and all other accessories, devices, power outlets or apparatuses installed specifically for the purpose of delivering energy from the premises wiring to the electric vehicle and allowing communication between them as necessary.

3.1.119 Supply Equipment Communication Controller (SECC)

entity which implements the communication to one or multiple electric vehicle communication controllers (EVCCs) according to IS/ISO 15118-2 and which may be able to interact with secondary actors.

3.2 Insulation

3.2.101 Isolation

Function intended to make dead for reasons of safety all or a discrete section of the electrical installation by separating the electrical installation or section from every source of electric energy.

3.2.102 (Electrically) Protective Separation

Separation of one electric circuit from another by means of:

- a) double insulation; or
- b) basic insulation and protective screening (shielding); or
- c) reinforced insulation.

3.3 Functions

3.3.101 Control Circuit

Circuit for signal and digital communication with vehicle, and for the management of charging control process.

3.3.102 d.c. Charging Control Function (DCCCF)

A function embedded in a d.c. electric vehicle supply equipment which controls d.c. power output following VCCF direction.

3.3.103 d.c. Charging/Discharging Control Function (DCCDCF)

A function embedded in a d.c. electric vehicle charging/discharging supply equipment which controls d.c. power input/output following VDCDF request.

3.3.104 Vehicle Charging Control Function (VCCF)

A function in a vehicle which controls the charging parameters of off-board d.c. electric vehicle supply equipment.

3.3.105 Vehicle Charging/Discharging Control Function (VDCDF)

A function in a vehicle which controls the charging/discharging parameters of off-board d.c. electric vehicle charging/discharging supply equipment.

3.3.106 Normal Shutdown

Termination of the charging process initiated by the user, by the vehicle or by the d.c. electric vehicle supply equipment, and not caused by a failure.

3.3.107 Error Shutdown

Termination of the charging process caused by a failure detected by the d.c. electric vehicle supply equipment or the vehicle.

3.3.108 Emergency Shutdown

Urgent termination of the charging process caused by a failure detected by the d.c. electric vehicle supply equipment or the vehicle, that may present a safety hazard.

NOTE — It may be done by disconnecting the d.c. electric vehicle supply equipment from supply network.

3.3.109 Thermal Sensing

Method for obtaining temperature data of accessories, cable assemblies or parts thereof.

3.3.110 Thermal Transport

Method for managing the heat dissipation of accessories, cable assemblies or parts thereof, independent of changing the current.

3.3.111 Thermal Sensing Device

Means for providing temperature data of accessories, cable assemblies or parts thereof.

3.3.112 Thermal Transport Device

Means for managing heat dissipation of accessories, cable assemblies or parts thereof, independent of changing the current.

3.3.113 Thermal Exchange

Method for cooling and dissipating thermal energy from the thermal transport.

3.3.114 Thermal Exchange Device

Means for cooling and dissipating thermal energy from the thermal transport.

3.3.115 Thermal Management System

System having thermal sensing, thermal exchange and thermal transport in order to keep the temperature in the allowed limit.

3.3.116 High Level Communication (HLC)

Bi-directional digital communication using protocol and messages and physical and data link layers specified in IS 17017 (Part 24).

3.4 Vehicle**3.4.101 Maximum Voltage Limit**

Upper limit value of charging voltage sent by the vehicle to the d.c. electric vehicle supply equipment.

3.4.102 Maximum Discharging Current of the Vehicle

Maximum limit of the discharging current of the vehicle which may change over time.

3.4.103 Maximum Charging Current of the Vehicle

Maximum limit of the charging current of the vehicle which may change over time.

3.5 Cords, Cables and Connection Means**3.5.101 Y-Capacitance**

Total capacitance bridging the isolation barriers of the d.c. output to other circuits and earth.

NOTES

1 The capacitors are of a type suitable for use in situations where failure of the capacitor could lead to danger of electric shock.

2 The total capacitance is commonly distributed equally between the two d.c. rails.

3.6 Service and Usage**3.6.101 Ordinary Person**

Person who is neither a skilled person nor an instructed person.

NOTE — Ordinary persons include users of the d.c. electric vehicle supply equipment, persons who may have access to the d.c. electric vehicle supply equipment, and who may be in the vicinity of the d.c. electric vehicle supply equipment. Under normal operating conditions, ordinary persons should not be exposed to energy sources causing startle reaction, pain or injury.

3.6.102 Skilled Person

Person with relevant education and experience to enable him or her to perceive risks and to avoid hazards which electricity can create.

3.6.103 Instructed Person

Person adequately advised or supervised by electrically skilled persons to enable him or her to perceive risks and to avoid hazards which electricity can create.

3.6.104 Restricted Access

Access to the d.c. electric vehicle supply equipment, limited, *for example*, by private housing, private camping areas or similar places.

3.6.105 Non-Restricted Access

Unlimited access to the d.c. electric vehicle supply equipment for all persons, *for example*, public areas.

3.7 General Terms**3.7.101 Primary Circuit**

A circuit that is directly connected to the a.c. or d.c. supply network, and includes the primary windings of transformers, other loading devices and the means of connection to the supply network.

3.7.102 Secondary Circuit

A circuit that has no direct connection to a primary circuit and derives its power from a transformer, converter or equivalent isolation device.

3.7.103 Rated Current

Input or output current under normal operating conditions assigned by the manufacturer.

3.7.104 Contact Assembly

Power contact with a terminal and additional component if any.

NOTE — *for example*, termination, contact support, thermal sensing, thermal transport etc.

3.7.105 Sleep Mode

Deactivation or performance reduction of internal subsystem in order to minimize power consumption.

3.7.106 d.c. Output Voltage

Voltage between d.c. power line terminals, that is between positive terminal DC+ and negative terminal DC-.

3.7.107 Touch Current

Electric current passing through a human body or through livestock when it touches one or more accessible parts of an installation or of equipment.

3.7.108 Touch Voltage

Voltage between conductive parts when touched simultaneously by a human or livestock.

NOTE — The value of the effective touch voltage may be appreciably influenced by the impedance of the person or the livestock in electric contact with these conductive parts.

3.7.109 Fire Enclosure

Part of the equipment intended to minimize the spread of fire or flames from within.

3.7.110 Enhanced Protection

Protective provision having a reliability of protection not less than that provided by two independent protective provisions.

3.7.111 PELV (System)

Electric system in which the voltage cannot exceed the value of extra low voltage under normal conditions and under single fault conditions, except earth faults in other electric circuits.

NOTE — PELV is the abbreviation for protective extra low voltage.

3.7.112 SELV (System)

Electric system in which the voltage cannot exceed the value of extra-low voltage under normal conditions and under single fault conditions, including earth faults in other electric circuits.

NOTE — SELV is the abbreviation for safety extra low voltage.

3.7.113 Power Electronic Converter System (PECS)

One or more power electronic converters intended to work together with other equipment

3.7.114 Protective Impedance

Impedance connected between hazardous live parts and accessible conductive parts, of such value that the current, in normal use and under likely fault conditions, is limited to a safe value, and which is so constructed that its ability is maintained throughout the life of the equipment.

3.7.115 Protective-Equipotential-Bonding

Equipotential bonding for purposes of safety (for example protection against electric shock).

3.7.116 (Electrically) Protective Screening

Separation of circuits from hazardous live-parts by means of an interposed conductive screen, connected to the means of connection for a PE conductor, either directly or via protective equipotential bonding.

3.7.117 Single Fault Condition

Condition in which one failure is present, which could cause a hazard covered by this document.

NOTES

1 If a single fault condition results in other subsequent failures, the set of failures is considered as one single fault condition.

2 Examples of hazards include, but are not limited to electric shock, fire, energy, mechanical, sonic pressure etc.

3.7.118 Startle Reaction

Physiological reaction due to a minimum derived value of touch voltage for a population for which a current flowing through the body is just enough to cause involuntary muscular contraction to the person through which it is flowing.

3.7.119 Working Voltage

Voltage, at rated supply conditions (without tolerances) and worst case operating conditions, that occurs by design in a circuit or across insulation.

NOTE — The working voltage can be d.c. or a.c. Both the r.m.s. and recurring peak values are used.

3.7.120 Insulation Monitoring Device (IMD)

Device which permanently monitors the insulation resistance to earth of unearthed a.c. IT systems, a.c. IT systems with galvanically connected d.c. circuits having nominal voltages up to 1 000 V a.c., as well as monitoring the insulation resistance of unearthed d.c. IT systems with voltages up to 1 500 V d.c., independent from the method of measuring

3.7.121 Earth Leakage Current Monitoring Device

Passive electrical device for monitoring insulation resistance of unearthed d.c. system by measuring leakage current between live parts and exposed conductive part or earth.

4 GENERAL REQUIREMENTS

This clause of IS 17017 (Part 1) is applicable, except as follows:

Replacement:

4.6 Not applicable.

5 CLASSIFICATION

This clause of IS 17017 (Part 1) is applicable except as follows:

Addition:

5.101 Category

5.101.1 According to the type of insulation between a.c. supply network and d.c. output circuit:

- basic insulation with conductive protective screening (shielding) that is provided with a means for electrical connection to the protective earthing conductor;
- reinforced insulation, and
- double insulation.

5.101.2 According to system control:

- a) regulated d.c. electric vehicle supply equipment:
 - 1) controlled current charging,
 - 2) controlled voltage charging, or
 - 3) combination of a) and b), and
- b) non-regulated d.c. electric vehicle supply equipment.

5.101.3 According to the system used:

- a) system A (*see* Annex A), or
- b) system C (*see* Annex B).

5.101.4 According to thermal management system:

- a) using thermal sensing;
- b) using thermal sensing and thermal transport; or
- c) none

6 CHARGING MODES AND FUNCTIONS

This clause of IS 17017 (Part 1) is applicable except as follows:

Replacement:

6.2 Charging Modes**6.2.1 Mode 1**

Not applicable

6.2.2 Mode 2

Not applicable

6.2.3 Mode 3

Not applicable

Replacement:

6.3 Functions Provided in Mode 4**6.3.1 Mandatory Functions in Mode 4****6.3.1.1 General**

The d.c. electric vehicle supply equipment shall supply a d.c. current or voltage to the vehicle battery in accordance with a VCCF request.

The following functions shall be provided by d.c. electric vehicle supply equipment as given below:

- a) continuous continuity checking of the protective conductor according to **6.3.1.2**;
- b) verification that the electric vehicle is properly connected to the electric vehicle supply equipment according to 6.3.1.3 of IS 17017 (Part 1);
- c) energization of the power supply to the electric vehicle according to **6.3.1.4**;

- d) de-energization of the power supply to the electric vehicle according to **6.3.1.5**;
- e) maximum allowable current according to **6.3.1.6** of IS 17017 (Part 1);
- f) d.c. supply for electric vehicle according to **6.3.1.101**;
- g) measuring current and voltage according to **6.3.1.102**;
- h) latching of the vehicle coupler according to **6.3.1.103**;
- j) compatibility assessment according to **6.3.1.104**;
- k) insulation check before charging according to **6.3.1.105**;
- m) protection against over voltage at the interface according to **6.3.1.106**;
- n) verification of vehicle connector latching according to **6.3.1.107**;
- p) control circuit supply integrity according to **6.3.1.108**;
- q) short circuit test before charging according to **6.3.1.109**;
- r) user initiated shutdown according to **6.3.1.110**;
- s) overload protection for parallel conductors (conditional function) according to **6.3.1.111**;
- t) voltage limitation between d.c. output and protective conductor according to **6.3.1.112** and **6.3.1.113**; and
- u) shutdown of d.c. electric vehicle supply equipment according to **6.3.1.114**, **6.3.1.115**, **6.3.1.116**, and **6.3.1.117**.

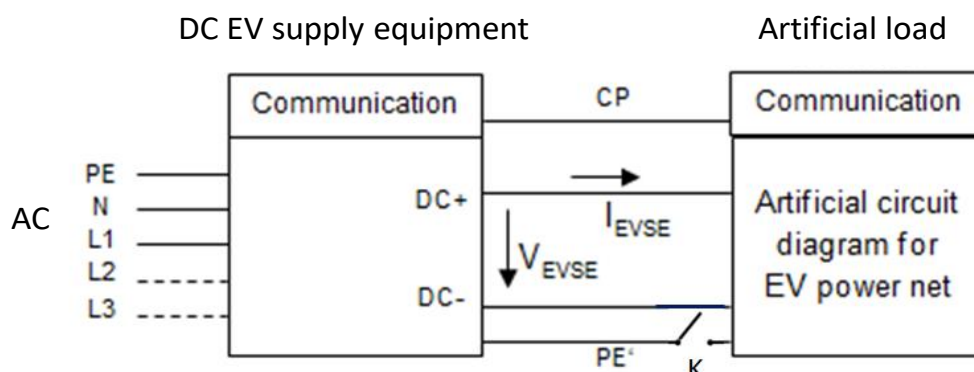
Replacement:

6.3.1.2 Continuous continuity checking of the protective conductor

The protective conductor continuity between the d.c. electric vehicle supply equipment and the vehicle shall be monitored continuously. For the rated voltage of d.c. 60 V or higher, the d.c. electric vehicle supply equipment shall trigger and completely execute an emergency shutdown within the time specified by Table 1 after a loss of electrical continuity of the protective conductor between d.c. electric vehicle supply equipment and electric vehicle.

Compliance for System A is checked by the following test. Compliance for System C is checked by **B-9.3.4**.

This test case applies to d.c. electric vehicle supply equipments with the maximum output voltage ≥ 60 V. The test system is shown in Fig. 1.



Key

K	switch or relay	L1, L2, L3	power line
CP	control pilot	I_{EVSE}	output current of electric vehicle supply equipment
PE	protective conductor	V_{EVSE}	output voltage of electric vehicle supply equipment
N	neutral contact		

NOTE — Artificial load refers to Fig. 26 and is specified in 102.2.3 unless otherwise specified.

FIG. 1 EFFECTIVE EARTH CONTINUITY TEST SYSTEM

The test shall be performed according to the following procedure:

- Connect the d.c. electric vehicle supply equipment to an artificial load with dedicated electric vehicle simulator for each system. For System A, electric vehicle simulator which has control pilot circuits shown in Fig. 29 shall be used. The control pilot circuits of test load shall comply with the requirement in A-3.14.
- Measure the voltage ($V_{EVSE \text{ output}}$) and current ($I_{EVSE \text{ output}}$) of the power line continuously.
- Start charging with the procedure specified by charger manufacturer.
- Confirm that the power flow of d.c. power line is at OP4 specified in Fig. 27.
- Open the relay K.
- Check that the d.c. electric vehicle supply equipment terminates the charging process and transfers to shutdown stage, displaying a relevant alarm or error information, if any.
- Check the result in Table 1.

Table 1 Verification Criterion
(Clause 6.3.1.2)

System	Verification Criterion
A	See Table 24

- Confirm that the d.c. power line between d.c. electric vehicle supply equipment and electric vehicle is de-energized to voltage less than 60 V.

NOTE — Protective conductor continuity is monitored by the control pilot, see A-3.2 and A-3.8.2 for System A and B-4.3 for System C.

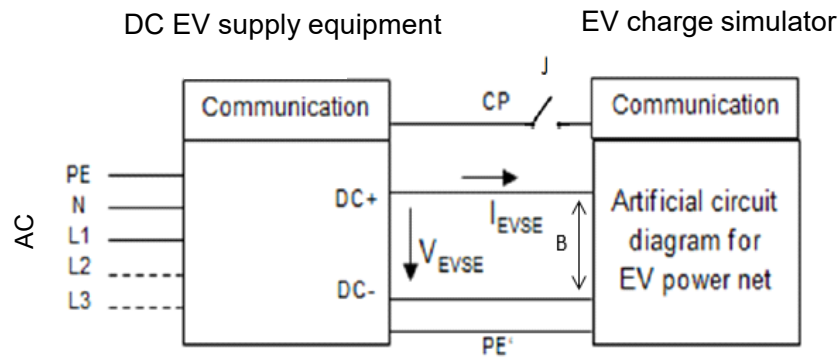
6.3.1.4 Energization of the power supply to the EV Addition:

Compliance is checked by the following test.

The test system is shown in Fig. 2.

The test shall be performed according to the following procedure:

- Connect the d.c. electric vehicle supply equipment to an artificial load with dedicated electric vehicle simulator for each system.
- Measure the voltage (V_{EVSE}) of the power line continuously.
- Simulate the open circuit of control pilot by opening the relay J. The control pilot lines to be tested for each system are shown below:
 - System A: CP3 (see Fig. 29)
 - System C: CP (see A-2 of IS 17017 (Part 1) : 2018)
- Start charging with the procedure specified by the manufacturer.
- Confirm that the power line at point B has not been energized.



Key

J	switch or relay	L1, L2, L3	power line
CP	control pilot	I_{EVSE}	output current of electric vehicle supply equipment
PE	protective conductor	V_{EVSE}	output voltage of electric vehicle supply equipment
N	neutral contact	B	voltage between DC + and DC- at the input of electric vehicle simulator

FIG. 2 CONTROL PILOT TEST SYSTEM

6.3.1.5 De-energization of the power supply to the EV*Addition:*

Compliance is checked for system A by the test in **A-3.2** and for system C by the test in **B-9.3.3**.

In the case of failure in control circuit of d.c. electric vehicle supply equipment, such as short-circuit, earth leakage, CPU failure or excess temperature, the d.c. electric vehicle supply equipment shall terminate the supply of charging current, and disconnect the supply of control circuit.

In the case where earth fault or overcurrent is detected, the conductor shall be disconnected from its supply.

Compliance is checked according to ISO 26262 or IEC 61508.

*Addition:***6.3.1.101 d.c. Supply for EV**

The d.c. electric vehicle supply equipment shall supply regulated d.c. voltage or current (not simultaneously, but as requested by the vehicle during charging) to the vehicle battery in accordance with VCCF's controlling. Requirements for charging performance of regulated d.c. current/voltage are given in **101.2.1**, **101.2.2**, **101.2.3**, **101.2.4**, **101.2.5** and **101.2.6**.

In either case mentioned above, the maximum ratings of the d.c. electric vehicle supply equipment shall not be exceeded.

Compliance is checked by measurement.

The vehicle can change the requested current and/or requested voltage.

NOTE — Electric vehicles are equipped with different technologies and different voltages of battery. In order to avoid any error during charging and to guarantee that the d.c. electric vehicle supply equipment will be able to charge all existing and future batteries, any charging process is controlled by the vehicle. Any vehicle that is to be connected to a d.c. electric vehicle supply equipment is equipped with a VCCF for controlling the charging process.

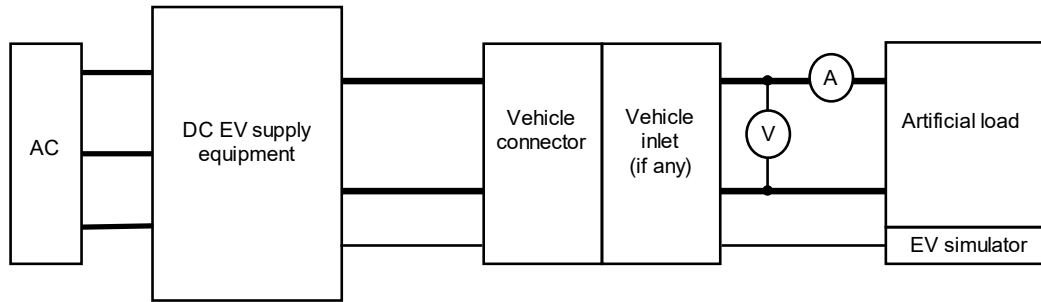
6.3.1.102 Measuring current and voltage

The d.c. electric vehicle supply equipment shall measure the output current and output voltage that is supplied to the electric vehicle. The accuracy of these measurements shall meet the defined accuracy for each system in **A-4.4** and **B-6.5**.

The measured values of voltage and current shall be provided by the d.c. electric vehicle supply equipment to the electric vehicle through digital communication.

Compliance for System A is checked by the following test. Compliance for System C is checked by **B-9.3.12** and **B-9.3.13**.

The test system is shown in Fig. 3.



Key

A Current measuring device

V Voltage measuring device

FIG. 3 D.C. SUPPLY TEST SYSTEM

The test shall be performed according to the following procedure:

- a) Connect the d.c. electric vehicle supply equipment to an artificial load with a dedicated electric vehicle simulator for each system.

NOTE — Artificial load indicates Fig. 26 unless otherwise specified.

- b) Start charging with the procedure specified by the manufacturer of d.c. electric vehicle supply equipment.
- c) Set the CCC target values at $I_{\max}$, I_{avg} and $I_{\min}$ of the d.c. electric vehicle supply equipment.
- d) Set the CVC target values at $V_{\max}$, V_{ave} and $V_{\min}$ of the d.c. electric vehicle supply equipment. For System A, the output voltage is set to $V_{\max}$, V_{ave} and $V_{\min}$ of the d.c. electric vehicle supply equipment by one of the following measures:
 - 1) the output current shall be adjusted to set the output voltage at $V_{\max}$, V_{ave} and $V_{\min}$ of the d.c. electric vehicle supply equipment with either the electronic load U1 operating at constant resistance mode or using the resistors R1 and R2 to set the voltage point; or
 - 2) electronic load U1 shall be operated under the constant voltage mode.
- e) Trend chart of output voltage and current which is measured at output terminals of the d.c. electric vehicle supply equipment and vehicle coupler.
- f) Check that the difference between the measured values of the d.c. electric vehicle supply equipment and the measuring instrument are within the limits specified in **A-4.4** or **B-6.5**.

$I_{\max}$, I_{avg} , $I_{\min}$, $V_{\max}$, V_{ave} and $V_{\min}$ are defined by each system.

System A:

$I_{\max}$ = Rated current specified by each manufacturer

$I_{\text{avg}} = I_{\max}/2$

$I_{\min} = 5\text{A}$

$V_{\max}$ = Maximum voltage specified by the manufacturer

$V_{\text{ave}} = (V_{\max} + V_{\min})/2$

$V_{\min}$ = Minimum voltage specified by the manufacturer

6.3.1.103 Latching of the vehicle coupler

A vehicle connector used for d.c. charging shall be latched on a vehicle inlet if the d.c. output voltage is higher than 60 V between DC+ and DC–, or higher than 28 V between DC+ and earthing terminal, and DC– and earthing terminal.

The vehicle connector shall not be unlatched (if the latching mechanism is engaged) when voltage exceeding 60 V d.c. is detected through the charging process including after the end of charging. In case of charging system malfunction, a means for safe disconnection may be provided.

NOTES

1 The actuation portion of the latching function can be in either the vehicle connector or the vehicle inlet.

2 Voltage criteria for latching/unlatching function can be lower than 60 V d.c.; for example, 10 V in System A.

The d.c. electric vehicle supply equipment shall have the following functions when the latching is done by the d.c. electric vehicle supply equipment:

- a) electrical or mechanical latching function to retain the latched status, and
- b) function to detect the disconnection of the electrical circuits for the latching function.

Compliance is checked by the following tests c) and d).

- c) Normal condition test — Simulate a normal charging operation. Check that the vehicle connector is latched on the vehicle inlet whenever the voltage at the inlet is higher than or equal to 60 V d.c. between DC+ and DC–, or higher than or equal to 28 V between DC+ and earthing terminal, and DC– and earthing terminal.
- d) Abnormal condition test Simulate a condition in which the voltage at the vehicle inlet remains higher than or equal to 60 V d.c. between DC+ and DC–, or higher than or equal to 28 V between DC+ and earthing terminal, and DC– and earthing terminal after the end of charging, for example by forcibly keeping the electric vehicle contactors closed. Check that the vehicle connector is latched on the vehicle inlet whenever the voltage at the inlet is higher than or equal to 60 V d.c. between DC+ and DC–, or higher than or equal to 28 V between DC+ and earthing terminal, and DC– and earthing terminal.

Additional requirements are given in **A-3.6** and **B-4.2**.

Vehicle connectors and vehicle inlets shall comply with the requirements of IS 17017 (Part 2/Sec 1) and IS 17017 (Part 2/Sec 3). *See also 9.101.*

6.3.1.104 Compatibility assessment

Compatibility of electric vehicle and d.c. electric vehicle supply equipment shall be checked with the information exchanged at the initialization phase of communication and charging process.

For system A, the d.c. electric vehicle supply equipment shall check the condition which the target battery voltage sent from electric vehicle is between the available output voltage and the minimum rated voltage specified by the manufacturer. In case this condition is not met, the d.c. electric vehicle supply equipment shall terminate the charging process.

For system C, the d.c. electric vehicle supply equipment checks that its minimum voltage is less than the maximum voltage of the electric vehicle battery. In case this condition is not met, the d.c. electric vehicle supply equipment terminates the charging process.

NOTE — General information of charging control and commutation are described in Annex F.

The compliance is checked by the following test.

- a) Connect the d.c. electric vehicle supply equipment to an artificial load with a dedicated electric vehicle simulator for each system.
- b) Start charging with the procedure specified by charger manufacturer.
- c) Using the electric vehicle simulator, transmit the data or message in Table 2 to the d.c. electric vehicle supply equipment via digital communication.

- d) For each case, check that the d.c. electric vehicle supply equipment terminates the charging process and transfers to shutdown stage, displaying a relevant alarm or error information, if any.
- e) For System A, perform the test separately for each case.
- f) For System C, *see B-9.3.1*.
- g) Confirm that the d.c. power line between the d.c. electric vehicle supply equipment and the electric vehicle is de-energized to voltage less than 60 V between DC+ and DC–, or less than 28 V between DC+ and earthing terminal, and DC– and earthing terminal.

Table 2 Data/Message for Transmission Test

(Clause 6.3.1.104)

System	Data/Message (refer to IS 17017(Part 24))	Value
A (Case 1)	Target battery voltage	420 V
	Maximum battery voltage	410 V
A (Case 2)	Target battery voltage	min (available output voltage +10 V, 595) V
	Maximum battery voltage	600 V
C	<i>see B-9.3.1</i>	

6.3.1.105 Insulation Check before Charging

The d.c. electric vehicle supply equipment shall confirm the insulation resistance between its d.c. output circuit and protective conductor to the vehicle chassis, including any exposed conductive part of the d.c. electric vehicle supply equipment, before the electric vehicle contactors are allowed to close.

If the required value is not met, the d.c. electric vehicle supply equipment shall trigger and perform an error shutdown, and indicate to the vehicle that the charging is not allowed.

For System A insulation resistance shall be measured as follows. For System C, *see B-4.1.3*.

For each output circuit, the appropriate relays in the d.c. output circuit of the d.c. electric vehicle supply equipment shall be closed during the insulation check.

The required value of insulation resistance R shall be as shown in Formula (1):

$$R \geq 100 \, \Omega/V \times U \quad (1)$$

where

U is rated output voltage of the d.c. electric vehicle supply equipment or maximum battery voltage of electric vehicle.

Details are specified in **A-4.3.3**.

Compliance is checked by the tests in **A-4.3.3**.

6.3.1.106 Protection against overvoltage between positive terminal DC+ and negative terminal DC– at the interface

The d.c. electric vehicle supply equipment shall trigger an error shutdown within the maximum time given in Table 3 to prevent overvoltage at the interface after occurrence of the fault.

Specific requirement for detection and shutdown are defined in Table 21.

NOTE — The vehicle can change the maximum voltage limit during charging process. The vehicle should consider some margin between the target battery voltage and maximum voltage limit communicated to the d.c. electric vehicle supply equipment to avoid unwanted stop of the charging process.

Table 3 Error Shutdown Trigger Timing

(Clause 6.3.1.106)

System	Fault	Maximum time after occurrence of the fault to trigger error shutdown
A	Output voltage exceeds the maximum voltage limit sent by the vehicle	2 s
C	Output voltage exceeds the maximum voltage limit sent by the vehicle for 400 consecutive milliseconds	10 ms

Compliance for System A is checked by the following test. Compliance for System C is checked by **B-9.3.6**.

The test shall be performed according to the following procedure:

- Connect the d.c. electric vehicle supply equipment to an artificial load with a dedicated electric vehicle simulator appropriate for the system under test. The setup of the test load in Fig. 26 is in Table 4.

Table 4 Test Load Setup

(Clause 6.3.1.106)

System	Switches					Circuit parameter setup
	S0	S1	S3	Sa	Sb	
A	close	close	open	open	close	L1: 0 H R1, R5: 0 Ω (bypassed) V1: Not used U1: An electronic load operating under constant voltage mode shall be used.

- Measure the voltage ($V_{EVSE\ output}$) and current ($I_{EVSE\ output}$) of the power line continuously.
- Start charging with the procedure specified by charger manufacturer.

- Using the electric vehicle simulator, transmit the data or message in Table 5 to the d.c. electric vehicle supply equipment via digital communication.

Table 5 Data/Message for Transmission Test

(Clause 6.3.1.106)

System	Data /Message Name	Value
	Target battery voltage	410 V
A	Maximum battery voltage	420 V
	Target battery current	$I_{EVSE\ max}$

- Confirm that the d.c. power line between the d.c. electric vehicle supply equipment and the electric vehicle is energized at the rated voltage and the d.c. electric vehicle supply equipment is operating at the designated voltage and current.
- Simulate overvoltage at the interface by the method(s) in Table 6 and check the results.

Table 6 Charging Stop Method

(Clause 6.3.1.106)

System	Method(s) to simulate overvoltage at the interface	Verification criterion
A	Set U1 = voltage higher than the maximum battery voltage	see Table 21.

- Check that the d.c. electric vehicle supply equipment terminates the charging process and transfers to shutdown stage, displaying a relevant alarm or error information, if any.

6.3.1.107 Verification of vehicle connector latching

This clause is only applicable for supply equipments which are responsible for latching of vehicle connector, such as System A

The d.c. electric vehicle supply equipment shall not energize the charging cable when the vehicle connector is unlatched.

Compliance is checked by inspection, operation and, for System A, the following test.

- A vehicle inlet shall be prepared with a modification in which the latch holder (hole) of the inlet is covered by a metal plate or an equivalent hard material that inhibits the latch holding of the vehicle connector (see Fig. 4).

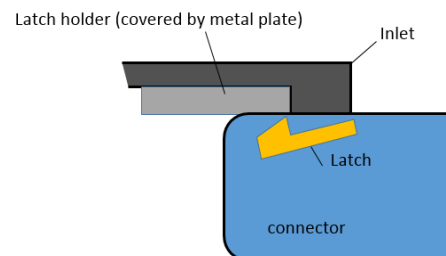


FIG. 4 EXAMPLE OF VEHICLE INLET WITH THE LATCH HOLDER COVERED BY A METAL PLATE THAT INHIBITS LATCH HOLDING

- b) Connect the d.c. electric vehicle supply equipment to an artificial load and a dedicated electric vehicle simulator.
- c) Start charging with the procedure specified by the manufacturer.
- d) Confirm that the d.c. output voltage does not exceed 60 V, and 28 V between DC+ and earthing terminal and DC– and earthing terminal, and the d.c. electric vehicle supply equipment terminates the charging process and transfers to shutdown stage, displaying a relevant alarm or error information, if any.

6.3.1.108 Control Circuit Supply Integrity

If an earth fault, short circuit or overcurrent is detected in the output circuit of d.c. electric vehicle supply equipment, the power circuit shall be disconnected from its supply, but the power supply for control circuit shall not be interrupted until the charging sequence is completed and the vehicle coupler is safely unlatched.

The compliance is checked by the following tests according to Table 7.

Table 7 Control Circuit Supply Integrity Test
(Clause 6.3.1.108)

Fault Scenario	System A	System C
Earth fault	Test a)	B-9.3.16.2
Short circuit	Test b)	B-9.3.18
Overcurrent	Design review	B-9.3.18

a) Earth-fault test

The test system is shown in Fig. 5.

The test shall be performed according to the following procedure:

- 1) An artificial load (*see 102.2.3*) with a dedicated electric vehicle simulator for each system is connected to d.c. electric vehicle supply equipment correctly under normal operation.
- 2) d.c. output voltage is at the rated value.
- 3) The d.c. electric vehicle supply equipment is operated in the constant voltage control mode (in case of System C) and constant current control mode (in case of System A).
- 4) Simulate the earth-fault by changing the position of the relay or switch L from open to 1.
- 5) Check that the earth-fault is detected properly and the d.c. electric vehicle supply equipment transfers to a fault state.
- 6) Confirm that the voltage of the power supply for control circuit at point A remains the same or within a specified range that ensures the normal operation of the control circuit.

- 7) Check that the d.c. electric vehicle supply equipment terminates the charging process and transfers to the error shutdown stage according to **6.3.1.116**.

- 8) Repeat the procedures 1) to 7) for the case in which the position of the relay or switch L is changed from open to 2 in 4).

b) Short-circuit test

The test system is shown in Fig. 6.

The test shall be performed according to the following procedure:

- 1) An artificial load with dedicated electric vehicle simulator for each system is connected to the d.c. electric vehicle supply equipment correctly under normal operation. If an electronic load is used, it shall not interfere with the measurement.
- 2) The power line (B) is energized at the rated voltage.
- 3) The d.c. electric vehicle supply equipment is operated in the constant voltage control mode (in case of System C) and constant current control mode (in case of System A).
- 4) Simulate the short circuit by closing the relay or switch M.
- 5) Check that the short circuit is detected properly and the d.c. electric vehicle supply equipment transfers to a fault state.
- 6) Confirm that the voltage of the power supply for control circuit at point A remains the same or within a specified range that ensures the normal operation of the control circuit.
- 7) Check that the d.c. electric vehicle supply equipment terminates the charging process and transfer to error shutdown for System A. Confirm that the measured d.c. voltage at point B is less than 60 V within 1 s for System A after the d.c. electric vehicle supply equipment detects the short circuit in 5).

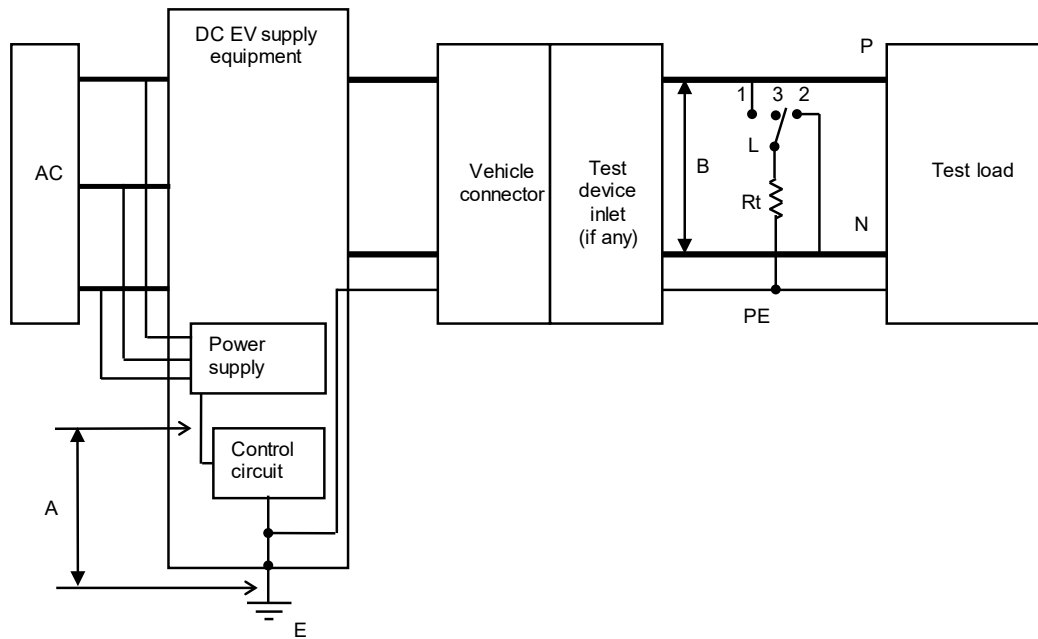
6.3.1.109 Short-Circuit check before charging

With the electric vehicle connected to the d.c. electric vehicle supply equipment and before the electric vehicle contactor is closed, the d.c. electric vehicle supply equipment shall have a means to check for a short circuit between d.c. output circuit positive and negative up to the electric vehicle contactor.

If short circuit is detected, the d.c. electric vehicle supply equipment shall trigger and perform an error shutdown.

Compliance for System A is checked by the following test. For system C, see **B-9.3.21**.

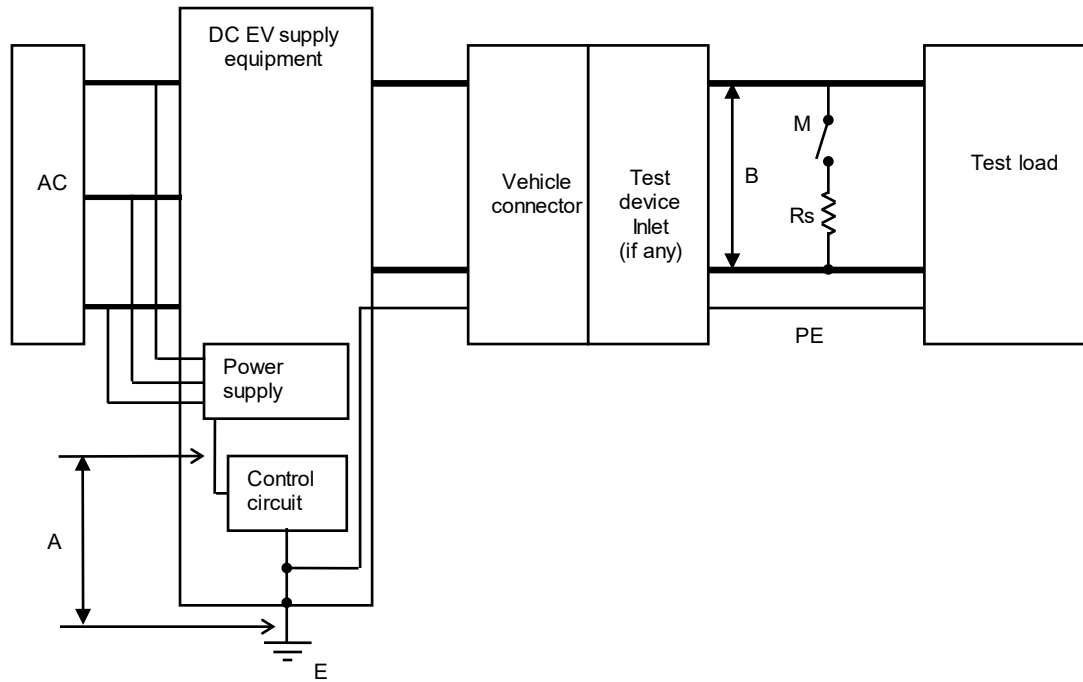
The test system is shown in Fig. 7.



Key

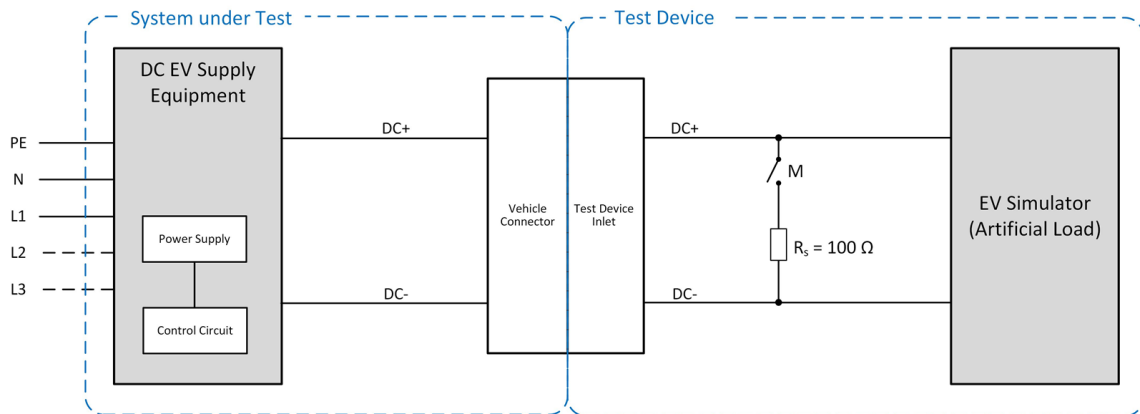
A	voltage of the power supply for control circuit	N	DC –
B	d.c. output voltage	P	DC +
E	earth	PE	protective conductor
L	selector switch	Rt	earth-fault resistance
1	terminal 1 to replicate earth-fault between P and E		
2	terminal 2 to replicate earth-fault between N and E		
3	open position of selector switch L		

FIG. 5 EARTH-FAULT TEST SYSTEM



- A voltage of the power supply for control circuit
 B voltage of the power line
 M switch or relay to replicate short-circuit
 Rs short circuit resistor (100 mΩ)

FIG. 6 SHORT-CIRCUIT TEST SYSTEM FOR TESTING CONTROL CIRCUIT INTEGRITY

**Key**

- M switch or relay
 Rs short-circuit resistance

FIG. 7 SHORT CIRCUIT TEST SYSTEM TO CHECK THE SHORT CIRCUIT BEFORE CHARGING

The test shall be performed according to the following procedure:

- a) Connect the d.c. electric vehicle supply equipment to an artificial load with dedicated electric vehicle simulator for each system.
- b) The electric vehicle contactors are open.
- c) The short-circuit resistance R_s shall be 100 Ω .
- d) Switch M is open.
- e) Simulate the short circuit of the power line by closing the switch M.
- f) Start charging with the procedure provided by charger manufacturer.
- g) The d.c. electric vehicle supply equipment shall terminate charging process by error shutdown before electric vehicle contactors are allowed to close.

6.3.1.110 User initiated Shutdown

The d.c. electric vehicle supply equipment shall have a means to allow the user to initiate the normal shutdown.

NOTE — For System A, a means to trigger an error shutdown is also possible.

Compliance is checked by the tests in **A-8** or **B-9.3.20**.

6.3.1.111 Overload Protection for Parallel Conductors (Conditional Function)

If more than one conductor or wire and/or vehicle connector contact is used in parallel for d.c. current supply to the vehicle, the d.c. electric vehicle supply equipment shall have a means to ensure that none of the conductors or wires will be overloaded.

Compliance is checked by design review.

NOTE — For example, the currents on the different path can be monitored or more than one power source can be used.

6.3.1.112 Maximum voltage between DC+/- and protective conductor in conditions without earth fault

Under normal operation no voltage higher than the d.c. output voltage plus 50 V shall occur between d.c. power line terminals (DC+ as positive terminal, and DC- as negative terminal) and protective conductor at the output of the d.c. electric vehicle supply equipment. This voltage limitation does not apply for transient overvoltages (see Fig. 8 and Fig. 9).

Components of d.c. electric vehicle supply equipment, for example an IMD, may superimpose a common mode voltage to protective conductor onto the d.c. output. At low output voltage this may shift the d.c. rails up to d.c. output voltage + 50 V compared to protective conductor.

Component of d.c. electric vehicle supply equipment may shift each d.c. output rail up to protective conductor through a resistor, which results in a large common mode output voltage swing.

The measurement circuits might introduce a larger common mode voltage offset if connected to an intermediate bus voltage. These circuits shall not cause a voltage shift that exceeds the requirements in **6.3.1.112**.

Fig. 9 shows an example of an incorrect implementation.

6.3.1.113 Maximum voltage between DC+/- and protective conductor in conditions with a single earth fault

For d.c. electric vehicle supply equipments serving a maximum rated output voltage up to 500 V, no voltage higher than 550 V shall occur for more than 5 s at the output between DC+ and protective conductor or between DC- and protective conductor (see Fig. 10).

If a voltage higher than 550 V is present for more than 1 s between DC+ and protective conductor or between DC- and protective conductor, the d.c. electric vehicle supply equipment shall have completed an error shutdown within 5 s after occurrence of the overvoltage.

For d.c. electric vehicle supply equipments serving a maximum output voltage above 500 V and up to 1 000 V, no voltage higher than 110 percent of d.c. output voltage shall occur for more than 5 s at the output between DC+ and protective conductor or between DC- and protective conductor.

If a voltage higher than 110 percent of the d.c. output voltage is present for more than 1 s between DC+ and protective conductor or between DC- and protective conductor, the d.c. electric vehicle supply equipment shall have completed an error shutdown within 5 s after occurrence of the overvoltage.

For voltage above 1 000 V, under consideration.

Within the first 5 s of an earth fault condition, the d.c. electric vehicle supply equipment shall limit the temporary overvoltage V_{tov} as defined in ISO 6469-3 and IS 15382 (Part 1) between DC+/- and protective conductor to:

$$(2 U_{min} + 1\,000) \times 1.41 \text{ V or;}$$

$$(U_{min} + 1\,200) \times 1.41 \text{ V, whichever is less.}$$

where

U_{min} is the minimum rated d.c. output voltage.

Fig. 11 shows an example of temporary voltage waveform and the maximum voltage limit at the d.c. output.

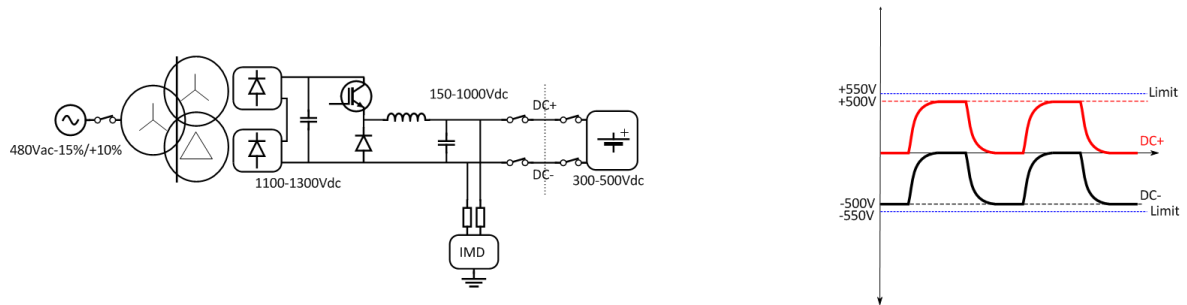


FIG. 8 TYPICAL VOLTAGES BETWEEN DC +/- AND PROTECTIVE CONDUCTOR IN CONDITIONS WITHOUT EARTH FAULT

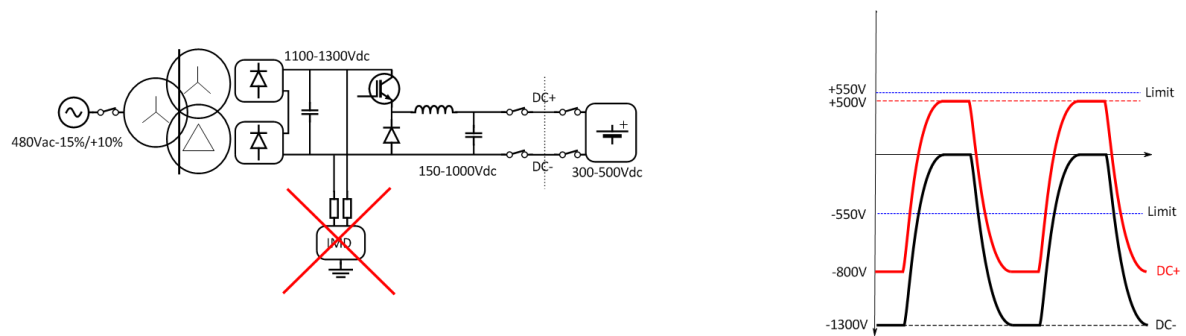


FIG. 9 IMD CONNECTION WHICH RESULTS IN EXCEEDANCE OF MAXIMUM VOLTAGE LIMITS

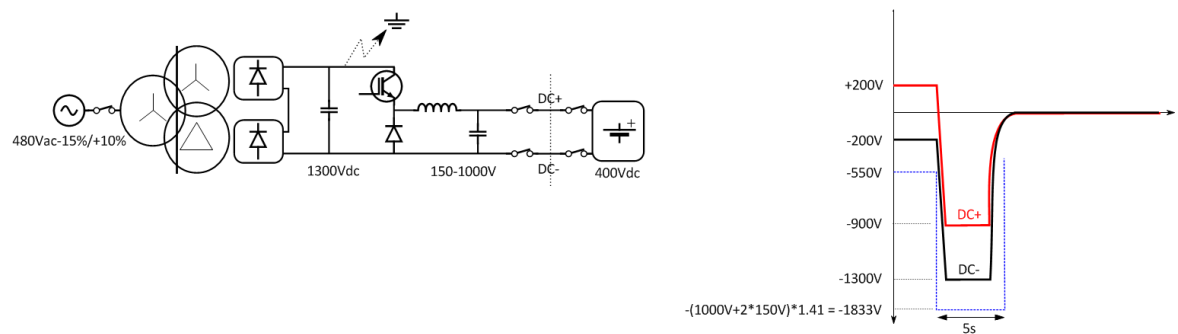
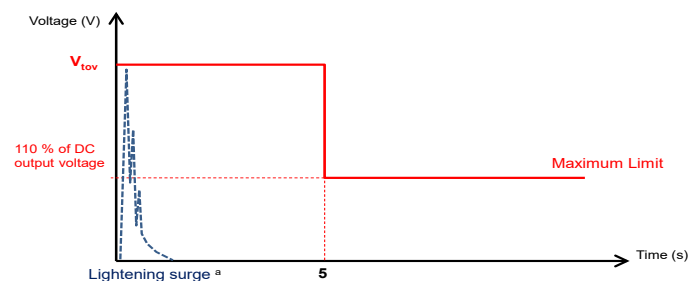


FIG. 10 MAXIMUM VOLTAGE BETWEEN DC+/- AND PROTECTIVE CONDUCTOR IN CONDITIONS WITH A SINGLE EARTH FAULT



EXAMPLE

^a Lightning surge appears at the common-mode d.c. output as a result of its input to the a.c. input circuit of d.c. electric vehicle supply equipment.

FIG. 11 EXAMPLES OF TEMPORARY VOLTAGE WAVEFORM AND THE MAXIMUM VOLTAGE LIMIT AT THE D.C. OUTPUT

6.3.1.114 Shutdown of d.c. EV Supply Equipment

At the end of a shutdown sequence, the d.c. electric vehicle supply equipment shall reduce d.c. output current to equal to or less than 5 A, and shall be designed such that d.c. output voltage remains equal to or less than 60 V between DC+ and DC–, and equal to or less than 28 V between DC+ and earthing terminal, and DC– and earthing terminal.

6.3.1.115 Normal Shutdown

Normal shutdown occurs as a result of an intrinsic reaction of the vehicle or the d.c. electric vehicle supply equipment or a user interaction, for other reasons than the presence of a failure.

At the end of the normal shutdown sequence, the d.c. electric vehicle supply equipment shall reduce its output as follows:

- a) d.c. output current ≤ 5 A;
- b) d.c. output voltage remains ≤ 60 V between DC+ and DC– and remains ≤ 28 V between DC+ and earthing terminal, and DC– and earthing terminal.

Further requirements are specified in **A-4.3.5.1** and **B-3.3**.

6.3.1.116 Error Shutdown

After the error shutdown is triggered by the d.c. electric vehicle supply equipment, the d.c. electric vehicle supply equipment shall reduce its output as follows:

- a) d.c. output current ≤ 5 A;
- b) d.c. output voltage remains ≤ 60 V between DC+ and DC– and remains ≤ 28 V between DC+ and earthing terminal, and DC– and earthing terminal, within times as specified in Annex A and Annex B.

Timing and further requirements to initiate an error shutdown are specified:

- a) for System A in **A-4.3.5.2**, Table 21 and Table 22;
- b) for System C in **B-3.4**.

NOTE — The compliance test verifies the shutdown time which consists of performance time plus trigger time as defined in the Clauses referring to error shutdown. The trigger time does not need to be verified provided shutdown time complies with the specific requirement.

6.3.1.117 Emergency Shutdown

After the emergency shutdown is triggered by the d.c. electric vehicle supply equipment, the d.c. electric vehicle supply equipment shall reduce its output as follows:

- a) d.c. output current ≤ 5 A within 30 ms;
- b) d.c. output voltage ≤ 60 V between DC+ and DC–, and ≤ 28 V between DC+ and earthing terminal, and DC– and earthing terminal within 1 s for Systems A and C.

NOTES

1 The compliance checks the total time, which consists of the timings above plus triggering time as defined in the Clauses referring to emergency shutdown. The trigger time does not need to be verified provided shutdown time complies with the specific requirement.

2 A welded contactor on the vehicle can prevent the d.c. electric vehicle supply equipment to reduce the voltage

Further requirements are specified in **A-4.3.5.3** and **B-3.4**.

Compliance for System A is checked by the following test. Compliance for System C is checked by **B-9.3.7** and **B-9.3.8**.

The test system is shown in Fig. 12.

The test shall be performed according to the following procedure:

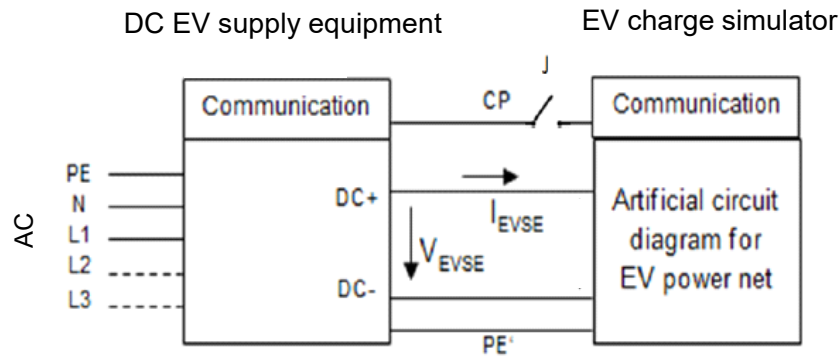
- a) Connect the d.c. electric vehicle supply equipment to an artificial load with dedicated electric vehicle simulator with load for each system.
- b) Start charging with the procedure specified by the manufacturer of d.c. electric vehicle supply equipment.
- c) Confirm that the d.c. power line between d.c. electric vehicle supply equipment and electric vehicle is energized at the rated voltage and the d.c. electric vehicle supply equipment is operating at the maximum rated output current.
- d) Initiate emergency shutdown for System A, according to Table 24 and Table 25
- e) The d.c. electric vehicle supply equipment shall terminate the charging process and transfer to shutdown stage, displaying a relevant alarm or error information, if any.
- f) The d.c. output voltage shall be less than 60 V within 1 s, and the voltage between DC+ and earthing terminal, and voltage between DC– and earthing terminal shall be less than 28 V.

Replacement of title 6.3.2:

6.3.2 Optional Functions for Mode 4**6.3.2.1 General**

The following functions, if provided by the d.c. electric vehicle supply equipment, shall comply with applicable clauses as given below:

- a) ventilation during supply of energy according to **6.3.2.2**;
- b) Mode 4 using the combined charging system according to **6.3.2.4**;
- c) wake up of d.c. electric vehicle supply equipment by electric vehicle according to **6.3.2.101**;
- d) detection/adjustment of the real time available load current of the d.c. electric vehicle supply equipment according to **6.3.2.102**.



Key

J	switch or relay	L1, L2, L3	power line
CP	control pilot	I_{EVSE}	output current of electric vehicle supply equipment
PE	protective conductor	V_{EVSE}	output voltage of electric vehicle supply equipment
N	neutral contact		

FIG. 12 EMERGENCY SHUTDOWN TEST SYSTEM

Other additional functions may be provided.

NOTES

- 1 Un-intentional live disconnect avoidance functions may be incorporated in the latching function interlock system.
- 2 A positive means to prevent unintentional disconnect is required.
- 3 Primary protection against overvoltage and overcurrent of vehicle battery is the responsibility of the vehicle.

Addition:

6.3.2.101 Wake Up of d.c. EV Supply Equipment by EV

The d.c. electric vehicle supply equipment may support a sleep mode to minimize power consumption. In this case, the d.c. electric vehicle supply equipment shall be able to be woken up by the electric vehicle.

For System A, the d.c. electric vehicle supply equipment shall be woken up by receiving the specific CAN ID from the vehicle.

Compliance is checked by the following test.

- a) Set d.c. electric vehicle supply equipment in sleep mode.
- b) Send a proper signal from electric vehicle simulator to d.c. electric vehicle supply equipment.
- c) The d.c. electric vehicle supply equipment shall:
 - 1) for System A, transmit CAN message ID: H'708 after receiving H'700 from the electric vehicle simulator as indicated in Table A.2 and Table A.3 of IS 17017 (Part 24).
 - 2) for System C, see **B-5.2**.

6.3.2.102 Detection/Adjustment of the Real Time Available Load Current of the d.c. EV Supply Equipment

The d.c. electric vehicle supply equipment may change the available current and shall transmit it to vehicle via digital communication. The vehicle should limit the current request value in accordance with the change in the available current. The current request value shall be less than or equal to the available current.

For specific requirements, see **A-7**.

7 COMMUNICATIONS

This clause of IS 17017 (Part 1) is applicable except as follows:

7.1 Digital Communication Between the EV Supply Equipment and the EV

Addition:

Protective measures defined in this standard shall not rely on communicated values between the d.c. electric vehicle supply equipment and electric vehicle.

Annex F provides general information on the communication and charging process between electric vehicle and d.c. electric vehicle supply equipment.

Requirements on the communication for bi-directional power flow control for System A are specified in Annex A.

Addition:

7.1.101 Basic Communication Interface

Typical interfaces of control pilot function on d.c. electric vehicle charging systems are specified in

Annex A and Annex B. Each system carries out control pilot function through the control pilot conductors and terminals specified in IS 17017 (Part 2/Sec 3).

8 PROTECTION AGAINST ELECTRIC SHOCK

Replacement:

8.101 General Provisions

8.101.1 General

Requirements for protection against electric shock shall be according to 4.4 of IEC 62477-1 : 2016, which provides safety requirements for power electronic converter systems (PECS) and equipment.

For the purposes of this document, the d.c. electric vehicle supply equipment is considered to be a type of PECS equipment.

Hazard based safety models according to IS/IEC 62368-1 : 2014 may be used to evaluate protection against electric shock.

Protection against the risk of electric shock and the hazard including the output circuit of d.c. electric vehicle supply equipment under conditions of intended use and reasonably foreseeable misuse shall be provided at least by one of the following measures.

- a) Basic protection and fault protection, *see* **8.102** and **8.103**;
- b) Enhanced protection, *see* **8.104**.

Protection under normal operating conditions is provided by basic protection, and protection under single fault conditions is provided by fault protection.

Specific protective measures for the secondary circuit supplying the d.c. output are provided in **8.105**.

Protection of the a.c. primary circuits of d.c. electric vehicle supply equipment may include an RCD according to **8.105.7**.

Specific requirements for protective measures for d.c. electric vehicle supply equipment having non-isolated d.c. output circuits are under consideration.

8.101.2 Intended Use and Reasonably Foreseeable Misuse

Considering intended use and reasonably foreseeable misuse:

- a) hazardous-live-parts shall not be accessible and accessible-conductive-parts shall not be hazardous live; and
- b) hazardous currents shall not be disconnected with the vehicle connector.

Compliance for hazardous-live-parts is checked according to **8.102**, **8.103** and **8.104**.

Compliance for hazardous currents is checked according to **6.3.1.103**.

8.101.3 Limitation of Touch Current or Touch Voltage

Under normal operating conditions and single fault conditions, an ordinary person shall be protected against a harmful electric shock by either:

- a) limiting the touch currents, or
- b) limiting the touch voltage.

Body impedance corresponding to water wet conditions in 3.1.8 of IS/IEC 60479-1 shall be considered under the normal operation conditions and single fault conditions.

Compliance for hazardous-live-parts is checked according to **8.102**, **8.103**, **8.104** and **8.105**.

NOTE — The skin of a sweating person or a person after immersion in seawater is not considered.

8.101.4 Threshold of Perception and Startle Reaction

Protective measures shall be provided to prevent startle reactions during intended use, before, during and after an energy transfer session, under normal conditions and during single fault conditions. During the normal operating conditions, perception may be possible.

For the current path, finger-to-feet at the interface and hand-to-feet at the chassis shall be considered.

Protection by means of limitation of touch current shall be provided, such that a steady-state touch current flowing between simultaneously accessible conductive parts shall not exceed:

- a) 0.5 mA a.c./2 mA d.c. under normal operation, and
- b) 3.5 mA a.c./10 mA d.c. under single fault condition

Additional protection shall be provided, such that in case of a double fault, touch current does not exceed the DC2 limit (line B) in Fig. 22 and Table 13 of IEC 60479-1 : 2018.

Compliance is checked by measurement according to **12.6**.

Protection by means of limitation of discharge energy shall be provided, such that discharge energy shall not exceed:

- a) 5 μ J under normal operation;
- b) 0.5 mJ under single fault condition.

Additional protection shall be provided, such that in case of a double fault, the discharge energy does not exceed the C1 limit in Fig. 23 of IEC 60479-2 : 2017.

Compliance is checked by design review.

8.102 Basic Protection

8.102.1 General

Basic protection in d.c. electric vehicle supply equipment is employed to prevent persons from touching hazardous live parts. It shall be provided by one or more of the measures given in **8.102.2**, **8.102.3**, **8.102.4**, and **8.102.5**.

8.102.2 Protection by Means of Basic Insulation of Live Parts

Protection by means of basic insulation of live parts in d.c. electric vehicle supply equipment shall be according to 4.4.3.2 of IEC 62477-1 : 2016.

Basic insulation shall be provided by solid insulation or clearance and/or creepage distance.

Any accessible conductive part is considered to be a hazardous live part if not separated from the live parts by required insulation.

Basic insulation shall be designed and tested to withstand the impulse voltages and temporary overvoltages for the circuits to which they are connected.

Compliance is checked by inspection and test.

Test shall be conducted according to 5.2.3.2 and 5.2.3.4 of IEC 62477-1 : 2016.

8.102.3 Protection by Means of Enclosures or Barriers

Protection by means of enclosures or barriers in d.c. electric vehicle supply equipment shall be according to 4.4.3.3 of IEC 62477-1 : 2016.

Enclosures shall be suitable for use in their intended environments.

The d.c. electric vehicle supply equipment shall have adequate mechanical strength and shall be so constructed that no hazard occurs when subjected to intended use and expected misuse over the expected lifetime.

It shall only be possible to open enclosures or remove barriers:

- a) with the use of a tool or key; or
- b) after de-energization of hazardous live parts.

For constructional requirements, see **12.109**.

8.102.4 Protection by Means of Limitation of Voltage

Basic protection by the provision of limitation of voltage is fulfilled where the following conditions are met:

- a) Steady-state touch voltage under normal operation does not exceeds the values in Table 8;
- b) Steady-state touch voltage under single fault condition does not exceed the values in Table 9;
- c) A non-recurring d.c. touch voltage under normal operation does not exceed the limit of Fig. A.11 of IEC 62477-1 : 2016;
- d) A non-recurring d.c. touch voltage under single fault condition does not exceed the limit of Fig. A.8 of IEC 62477-1 : 2016; and
- e) The voltage is supplied by one of the following sources:
 - 1) a safety isolating transformer for the auxiliary circuit including control pilot.

NOTE — Safety isolating transformers are those that comply with IEC 61558-2-6.

- 2) a source of voltage providing a degree of safety equivalent to that of a safety isolating transformer;

- 3) electrochemical (*for example*, battery).

Table 8 Touch Voltage Under Normal Operation (Water Wet)

(Clause 8.102.4)

Body Contact Area	a.c. (rms)	d.c.
Part of body	Basic protection required	
Hand		
Finger tip	8.0 V	22.0 V

NOTE — Values are derived from Fig. A.8, Fig. A.11, Table A.3 and Table 5 of IEC 62477-1:2016. The values are based on a current path from the contact area of the body to feet, with the person in standing position.

Table 9 Touch Voltage Under Single Fault Conditions (Water Wet)

(Clause 8.102.4)

Body Contact Area	a.c. (rms)	d.c.
Part of body	Basic protection required	
Hand		
Finger tip	12.0 V	28.0 V
Hand-to-feet	—	22.0 V

NOTES

1 Values are derived from Fig. A.8, Fig. A.11, Table A.2 and Table 5 of IEC 62477-1 : 2016. The values are based on a current path from the contact area of the body to feet, with the person in standing position.

2 If these values cannot be met under single fault conditions, protective separation is needed.

Compliance is checked by inspection and measurement.

8.102.5 Protection by Means of Limitation of Steady-State Touch Current

Limitation of steady-state touch current is a provision whereby touch current is limited to non-hazardous values. The limits are provided in **8.101.4**.

The protective impedance limiting the touch current shall comply with 4.4.5.4 of IEC 62477-1 : 2016.

The protective impedance shall be so designed and tested to withstand the impulse voltages and temporary overvoltages as tested according to 5.2.3.2 and 5.2.3.4 of IEC 62477-1: 2016.

Compliance is checked by measurement according to **12.6**.

8.103 Fault Protection**8.103.1 General**

Fault protection provides protection against bodily harm due to contact with hazardous electrical energy during and after failure of the basic protection.

Fault protection shall be provided by one or more of the following measures:

- a) protective equipotential bonding in **8.103.2** in combination with the protective conductor,
- b) automatic disconnection of supply in **8.103.4**,
- c) supplementary insulation in **8.103.5**, and
- d) electrically protective screening in **8.103.6**.

Fault protection shall be independent and additional to those for basic protection.

In case the d.c. electric vehicle supply equipment or the d.c. charging/discharging station can supply more than one vehicle simultaneously, independent protection means (overcurrent and fault current) for each vehicle connector shall be provided in accordance with one or more of the provisions in **8.103.2**, **8.103.3**, **8.103.4**, **8.103.5** and **8.103.6**.

8.103.2 Protective-Equipotential-Bonding

Protective-equipotential-bonding is a provision whereby items are bonded together to avoid hazardous touch voltages.

Protective-equipotential-bonding in d.c. electric vehicle supply equipment shall be according to 4.4.4.2 of IEC 62477-1 : 2016.

Compliance is checked by inspection.

8.103.3 Effective Earth Continuity between the Enclosure and the External Protective Circuit

Exposed conductive parts of the d.c. electric vehicle supply equipment shall be effectively connected to the terminal for the external protective earthing conductor, and the resistance from the conductive part to the terminal of the external protective earthing conductor shall not exceed 0.1 Ω .

Compliance is checked by the following test.

- a) Make verification using a resistance measuring instrument which is capable of driving a current of at least 10 A (a.c. or d.c.). Pass the current between each exposed conductive part and the terminal for the external protective conductor.
- b) Confirm that the resistance does not exceed 0.1 Ω .

NOTES

1 It is recommended to limit the duration of the test where low-current equipment otherwise may be adversely affected by the test.

2 Routine testing can be performed according to 5.2.3.11.4 of IEC 62477-1 : 2016.

8.103.4 Automatic Disconnection of Supply

Automatic disconnection of supply in d.c. electric vehicle supply equipment shall be according to 4.4.4.4 of IEC 62477-1 : 2016 except as follows:

The protective device may be provided in any suitable upstream part of the installation or d.c. electric vehicle supply equipment. The manufacturer of d.c. electric vehicle supply equipment shall give appropriate information for the installation of external protection. The information may be provided in a detailed electric diagram.

Compliance is checked by inspection and measurement.

8.103.5 Supplementary Insulation

Supplementary insulation in d.c. electric vehicle supply equipment shall be according to 4.4.4.5 of IEC 62477-1 : 2016.

Compliance is checked by inspection.

8.103.6 Electrically Protective Screening

Electrically protective screening in d.c. electric vehicle supply equipment shall be according to 4.4.4.7 of IEC 62477-1 : 2016. Electrically protective screening shall consist of a conductive screen interposed between hazardous-live-parts of the d.c. electric vehicle supply equipment and the part being protected, whereby the screen is separated from live parts by at least basic insulation.

The protective screen shall:

- a) be connected to the protective-equipotential-bonding system of the d.c. electric vehicle supply equipment and that interconnection shall comply with the requirements of 4.4.4.2 of IEC 62477-1 : 2016, and
- b) comply with the requirements for elements of the protective-equipotential-bonding system according to 5.3.3.3, 5.3.3.4 and 5.3.3.5 of IEC 61140:2016.

Compliance is checked by inspection.

8.104 Enhanced Protection

8.104.1 General

An enhanced protective provision shall provide both basic protection under normal conditions and protection under single fault conditions in accordance with one or more of the provisions specified in **8.104.2** and **8.104.3**.

8.104.2 Reinforced Insulation

Reinforced insulation in d.c. electric vehicle supply equipment shall be according to 4.4.5.2 of IEC 62477-1 : 2016.

Compliance is checked by inspection.

8.104.3 Protective Separation between circuits

Protective separation between circuits in d.c. electric vehicle supply equipment shall be according to 4.4.5.3 of IEC 62477-1 : 2016.

Compliance is checked by inspection

8.105 Requirements of the Isolated d.c. EV Supply Equipment

8.105.1 General

Between the d.c. circuit and the ordinary person, double insulation, reinforced insulation, or basic insulation and electrically protective screening (shielding), shall be used as basic and fault protection.

For System A and C, insulation monitoring or leakage current monitoring in the d.c. electric vehicle supply equipment shall detect the first fault and disconnect the supply or shutdown the transfer of energy. This is not protection against electric shock but can prevent a hazardous electric shock on a second fault.

For detailed description, refer to **A-3.1** and **B-4.1**.

The reaction time of the insulation monitoring device or earth leakage current monitoring device shall be according to **A-3.1.2** and **B-4.1.4**. The value of the Y capacitances shall ensure that the reaction time of the insulation monitoring device or earth leakage current monitoring device is not exceeded. In any case, Y capacitance shall be less than 500 nF per rail for d.c. electric vehicle supply equipment.

The limitation of stored energy in the Y-capacitors shall not be used as fault protection for the d.c. electric vehicle supply equipment.

Additional protection may be provided by limited impedance between the d.c. output and the protective conductor, including the connected electric vehicle (see **8.101.4** for the requirements for additional protection).

Requirements for the isolated d.c. electric vehicle supply equipment for protection against electric shock hazard are defined for each system in **A-3.1** and **B-4.1**.

Outside of a fire enclosure, DC+ and DC- shall be separated by double or reinforced insulation from each other and other circuits.

In case the d.c. electric vehicle supply equipment can supply more than one vehicle simultaneously, independent protection means (overcurrent and fault current) for each vehicle connector shall be used in order to ensure selectivity.

In addition, if the d.c. electric vehicle supply equipment has multiple d.c. outputs designed for simultaneous operation, each output circuit shall be isolated from each other by basic insulation, double or reinforced insulation.

NOTE — System A requires limitation of Y-capacitance of electric vehicle with battery voltage up to 500 V, such that the total stored energy per rail to protective conductor of charging system does not exceed 0.2 J under the worst case scenario.

8.105.2 Degrees of Protection Against Access to Hazardous-Live-Parts

IP ratings for enclosures of d.c. electric vehicle supply equipment shall fulfil at least IPXXC.

Compliance is checked by inspection and measurement.

8.105.3 Insulation Barriers

The d.c. electric vehicle supply equipment shall have insulation barriers as shown in Fig. 13. The d.c. electric vehicle supply equipment shall provide the minimum protective measures as defined in Table 10.

8.105.4 Stored Energy

8.105.4.1 Disconnection of plug and cable connected d.c. EV supply equipment

For plug and cable connected d.c. electric vehicle supply equipment, where the connection pins are accessible after unplugging, one second after disconnecting the standard plug from the standard socket-outlet, for instance as described in IEC TR 60083 : 2015 or IEC 60309-1, the voltage between any combination of accessible contacts of the standard plug shall be less than or equal to 28 V d.c. and 12 V a.c. (r.m.s.) or the stored energy available shall be less than 0.5 mJ.

Compliance is checked by inspection and by test with the electric vehicle disconnected according to 2.1.1.5 of IEC 60950-1 : 2005.

8.105.4.2 Loss of supply voltage to permanently connected d.c. EV supply equipment

The voltage between power lines or power lines and protective earthing conductor, when measured at the input supply terminals of the d.c. electric vehicle supply equipment, shall be less than or equal to 28 V d.c. and 12 V a.c. (r.m.s.) or the stored energy shall be less than or equal to 0.5 mJ within 5 s after disconnecting the power supply voltage to the d.c. electric vehicle supply equipment.

Compliance is checked by inspection and by test with no electric vehicle connected to the d.c. electric vehicle supply equipment according to 2.1.1.7 of IEC 60950-1 : 2005.

8.105.5 Disconnection from Vehicle

If the voltage between any contacts at the vehicle connector exceeds 28 V d.c. or 12 V a.c. (r.m.s.) during charging, the electric vehicle supply equipment shall comply with at least one of the following requirements:

- The energy between any contacts shall be below 0.5 mJ within 1 s after disconnection of the vehicle connector from the vehicle inlet (Case 1), and
- The voltage between any contacts shall be below or equal to 28 V d.c. and 12 V a.c. (r.m.s.) within 1 s after disconnection of the vehicle connector from the vehicle inlet (Case 2).

The voltage or energy shall be measured at the unmated vehicle connector.

The test shall be performed according to the following procedure:

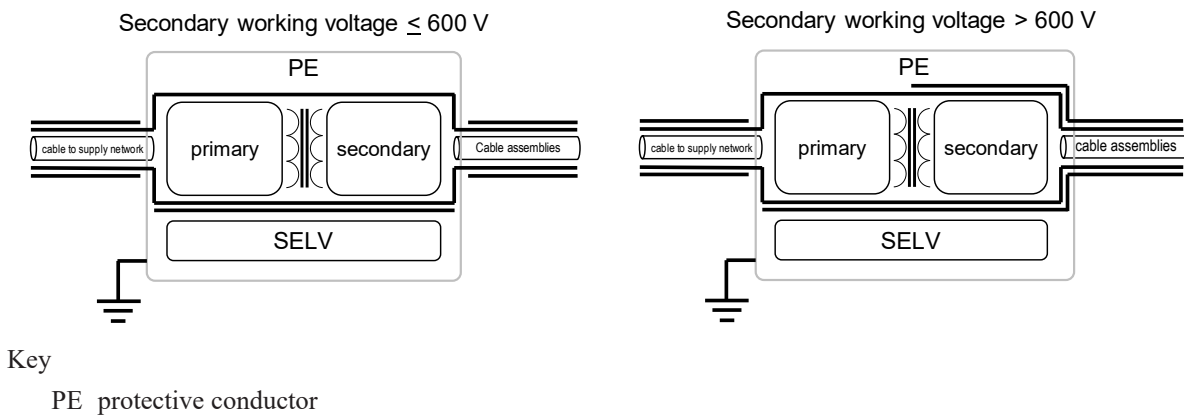


FIG. 13 INSULATION BARRIERS

Table 10 Minimum Protective Measures

(Clause 8.105.3)

	d.c.	SELV	Protective conductor	Ordinary person
a.c.	Protective separation	Protective separation	Single insulation ^a	Protective separation
d.c.	—	Protective separation ^b	Single insulation (< 600 V) Double insulation (> 600 V) ^c	Protective separation
SELV	—	—	Functional insulation ^d	None
Protective conductor	—	—	—	None

^a Local regulations may require double insulation. In some countries, extra monitoring of protective conductor is required when using single insulation. For some system, for example TT systems, double insulation to protective conductor is required up to the RCD, if one is installed in the d.c. electric vehicle supply equipment.

^b If the SELV circuit is connected to protective conductor and will not be damaged by the fault current, no hazardous voltages shall occur in the SELV circuit, and the IMD or earth leakage current monitoring device will detect the failure and trigger an error shutdown within 10 s (*under consideration*), single insulation between d.c. and SELV is allowed for some components, for example: contactors.

^c If on the secondary (d.c.) side, there is a circuit with a working voltage greater than 600 V, double insulation to the protective conductor is required. Additional protective measures are taken to limit the impedance to the protective conductor.

^d SELV may be connected to the protective conductor. If SELV is floating a 500 V r.m.s. test voltage may be applied to test the insulation.

- The d.c. electric vehicle supply equipment is connected to an artificial load as defined in **102.2.3**.
- The power line is energized at the maximum output voltage of the d.c. electric vehicle supply equipment.
- Start the measurement of voltage between each contact (P-N, P-GND and N-GND).
 - Stop charging based on the stop sequence defined by each system.
 - The test is passed:
 - for Case 1, if the stored energy at 1 s after disconnecting all the signal lines or the connector-latch circuit, if any, is less than the defined value. The energy is calculated

by using the corresponding values of capacitances determined before and the documented voltage 1 s after triggering. See Formula (2).

$$E = 0.5 \times C \times V^2 \quad (2)$$

where

E is the energy 1 s after triggering in Joule;

C is the capacity in Farad;

V is the voltage 1 s after triggering in Volt.

- for Case 2, if the voltage values between any contacts fall to less than 28 V in 1 s or less after disconnecting all the signal lines or the connector latch circuit, if any. For System A, the stored energy calculated by

Formula (2) in the output circuit of d.c. electric vehicle supply equipment also needs to be less than the value specified for Case 1.

8.105.6 Protective Earthing Conductor from Supply Network

The protective earthing conductor and the protective conductor from the supply network shall be of sufficient rating in accordance with requirements of 543.1.2 of IEC 60364-5-54 : 2011.

The d.c. electric vehicle supply equipment shall provide either:

- a) a protective earthing conductor from the input earthing terminal of the a.c. supply network to the d.c. electric vehicle supply equipment; or
- b) a protective conductor from the d.c. electric vehicle supply equipment to the electric vehicle if fault protection is based on protective separation. See requirements in **8.105.9**.

For permanently connected d.c. electric vehicle supply equipment, protective earthing conductors shall not be switched.

Protection Class II d.c. electric vehicle supply equipment shall have a lead-through protective conductor with double insulation or reinforced insulation for earthing the electric vehicle chassis.

Compliance is checked by inspection.

8.105.7 Residual Current Protective Devices

The d.c. electric vehicle supply equipment intended for fixed installation may rely on RCD(s) incorporated in the d.c. electric vehicle supply equipment and/or provided upstream by the installation as defined in the installation manual of the d.c. electric vehicle supply equipment and relevant wiring diagrams.

Plug and cable d.c. electric vehicle supply equipment shall be provided with RCD(s) within the d.c. electric vehicle supply equipment or on the cable or plug, and double insulation to the protective conductor is required between the plug and any parts not protected by RCD(s).

RCDs incorporated in d.c. electric vehicle supply equipment shall be at least of type A and comply with one of the following standards: IS 12640 (Part 1), IS 12640 (Part 2), or IS/IEC 60947-2.

RCDs incorporated on the cable, if any, shall be at least of type A and comply with IEC 61540.

RCDs shall disconnect all live conductors.

Manufacturer shall check compliance with RCDs incorporated in the d.c. electric vehicle supply equipments, or to be provided by the installation, by simulation or calculation of current in the protective conductor under normal and single fault conditions

according to the guideline provided in Annex H of IEC 62477-1 : 2016.

Plug and cable d.c. electric vehicle supply equipments shall always be designed such that under normal and fault conditions any resulting d.c. component of the current in the protective conductor never exceed 6 mA.

Compliance is checked by inspecting the construction and documents provided by the manufacturer.

NOTE — Limitation of d.c. component of the current in the protective conductor can be achieved by double or reinforced insulation of the circuit that can cause a d.c. leakage current to any other circuit and protective conductor, or d.c. leakage detection that disconnects the circuit that causes excessive d.c. leakage current.

8.105.8 Safety Requirements for Signalling Circuits between the d.c. EV Supply Equipment and the EV

Any circuit for signalling, which extends beyond the d.c. electric vehicle supply equipment enclosure for connection with the electric vehicle, for example control pilot circuit, shall be extra low voltage (SELV or PELV) according to IEC 62477-1.

Compliance is checked by inspection.

8.105.9 Protective Conductor Dimension Cross-Sectional Area

The protective earthing conductor or protective conductor of the secondary circuit of d.c. electric vehicle supply equipment shall be designed according to **A-3.1.1** or **B-4.7**.

Compliance is checked by inspection and measurement.

9 CONDUCTIVE ELECTRICAL INTERFACE REQUIREMENTS

This clause of IS 17017 (Part 1) is applicable except as follows:

9.1 General

Replacement:

The physical conductive electrical interface requirements between the vehicle and the d.c. electric vehicle supply equipment are as defined in IS 17017 (Part 2/Sec 3).

9.2 Functional Description of Standard Accessories

Not applicable.

9.7 Wiring of the Neutral Conductor

Not applicable except the following:

Wiring instructions shall be provided in the manual (see **16.1**).

Addition:

9.101 Avoidance of Breaking Under Load

For d.c. charging, the vehicle couplers are rated “not for current interruption.” A disconnection shall not take place under load.

In addition to latching mechanism defined in **6.3.1.103**, in case of unintended disconnection of the vehicle coupler, the output current of the d.c. electric vehicle supply equipment shall be turned off within a defined time to contain a possible arc within the vehicle coupler housing. This turn-off time shall comply with the value specified in **A-3.8.2**, **B-4.3** using a speed of separation of the vehicle connector of 0.8 ± 0.1 m/s according to IS 17017 (Part 2/Sec 1).

Disconnection of vehicle coupler shall be detected by interruption of interlock circuit(s), for example control pilot, proximity circuit, to mitigate electrical arcing and shock hazards.

Compliance is checked by the test in **6.3.1.117**.

The system specific requirement for breaking capacity and system redundancy are defined in **A-3.6** and **A-3.8.2** for System A and **B-4.3** for System C.

10 REQUIREMENTS FOR ADAPTORS

This clause of IS 17017 (Part 1) is applicable.

11 CABLE ASSEMBLY REQUIREMENTS

This clause of IS 17017 (Part 1) is applicable, except as follows.

Addition:

11.101 Cable Breakaway

The cable shall be connected to the enclosure in such a way that, if the cable anchorage fails, the conductors break in the following sequence:

- first, the control pilot conductor/conductors;
- second, the current carrying conductors;
- third, the protective earthing conductor, if any.

12 EV SUPPLY EQUIPMENT CONSTRUCTIONAL REQUIREMENTS AND TESTS

This clause of IS 17017 (Part 1) is applicable except as follows:

12.1 General

Addition:

The d.c. electric vehicle supply equipment shall comply with the restrictions/limitations as specified in the data sheet of the cable assembly manufacturer.

Compliance is checked by inspection.

12.3 Clearances and Creepage Distances

Replacement of the First paragraph:

The clearance and creepage distances in the electric vehicle supply equipment, installed as intended by the manufacturer, shall be in accordance with the requirements specified in IEC 62477-1.

Addition:

The d.c. output circuit of a d.c. electric vehicle supply equipment shall be designed according to a rated impulse voltage of at least 2 500 V.

Compliance is checked according to 12.7 of IS 17017 (Part 1) : 2018.

12.4 IP Degrees

12.4.1 Degrees of Protection Against Solid Foreign Objects and Water for the Enclosures

Addition:

For the d.c. electric vehicle supply equipment of stationary type, the test conditions can be defined in accordance with installation conditions.

12.5 Insulation Resistance

Addition:

Insulation resistance does not include components bridging insulation according to **12.109** and IMD or earth leakage current monitoring device.

When the d.c. output is energized, the actual total physical insulation resistance of the d.c. electric vehicle supply equipment between DC+/- to protective earthing conductor, that will not result in a shutdown, shall limit the touch current within the DC-2 area of Fig. 22 of IEC 60479-1 : 2018.

NOTES

- 1 The test is made without an insulation monitoring system.
- 2 The actual total physical insulation resistance is a combination of the impedance of the all components within the d.c. electric vehicle supply equipment and the electric vehicle.
- 3 The measured insulation resistance does not include the impedance of the insulation resistance measurement device.

12.6 Touch Current

This clause of IS 17017 (Part 1) does not apply except Table 1.

Addition:

12.6.101 Touch-Current Limit

The touch current between any a.c supply network poles and the accessible metal parts connected with each other and with a metal foil covering insulated external parts shall not exceed the values indicated in Table 1 of IS 17017 (Part 1).

The test shall be made when the d.c. electric vehicle supply equipment is functioning with an artificial load according to Fig. 26 at rated output power.

For permanently connected Class I d.c. electric vehicle supply equipment, if the test touch current exceeds 3.5 mA, **12.6.103** is applicable.

Circuitry which is connected through a fixed resistance or referenced to protective earthing conductor, for example electric vehicle connection check, should be disconnected before this test.

Compliance is checked by the test in 12.6.102.

12.6.102 Test

12.6.102.1 Test configuration

Test configurations for measurement of leakage current shall be according to 5.4.1 of IEC 60990 : 2016.

12.6.102.2 Application of Measuring Network

The measuring network is defined in Fig. 14. Terminal A of the measuring network is connected to each conductive or unearthed accessible surface in turn. For each application of the terminal A electrode, the terminal B electrode is applied to earth, then to each of the other accessible parts in turn. All accessible conductive or unearthed surfaces are to be tested for touch currents.

For an accessible non-conductive part, the test is made to metal foil having dimensions of 100 mm by 200 mm in contact with the part.

For accuracy of touch current measuring instruments, see G.3 of IS/IEC 60990 : 2016.

12.6.102.3 Test condition

The touch current shall be measured after the damp heat test, with the d.c. electric vehicle supply equipment connected to a.c. supply network in accordance with 6 of IS/IEC 60990:2016. The supply voltage shall be 1.1 times the nominal rated voltage.

Measurements shall be made with each of the applicable fault conditions in accordance with 6.2.2 of IEC 60990 : 2016.

12.6.102.4 Test measurements

The r.m.s. value of the voltage, U_2 , shall be measured using the measuring instrument in Fig. 14. Formula (3) shall be used to calculate the touch current:

$$\text{Touch Current(A)} = U_2/500 \quad (3)$$

None of the values measured in accordance with 12.6.102.2 shall exceed the relevant limits specified in 12.6.101.

12.6.103 Protection Measures for the Touch Current Exceeding 3.5 mA

For the a.c. supply circuit of a Class I d.c. electric vehicle supply equipment, if the test touch current exceeds 3.5 mA r.m.s, one of the following requirements shall be met. The touch current shall be measured under the fault condition with earthing conductor closed.

- The protective earthing conductor shall have a cross-sectional area of at least 10 mm² Cu or 16 mm² Al, through its total run;
- Where the protective earthing conductor has a cross-sectional area of less than 10 mm² Cu or 16 mm² Al, a second protective earthing conductor of at least the same cross-sectional area shall be provided up to a point where the protective earthing conductor has a cross-sectional area not less than 10 mm² Cu or 16 mm² Al;

NOTE — (b) can require that the d.c. electric vehicle supply equipment has a separate terminal for a second protective earthing conductor.

- Automatic disconnection of the supply in case of loss of continuity of the protective earthing conductor.

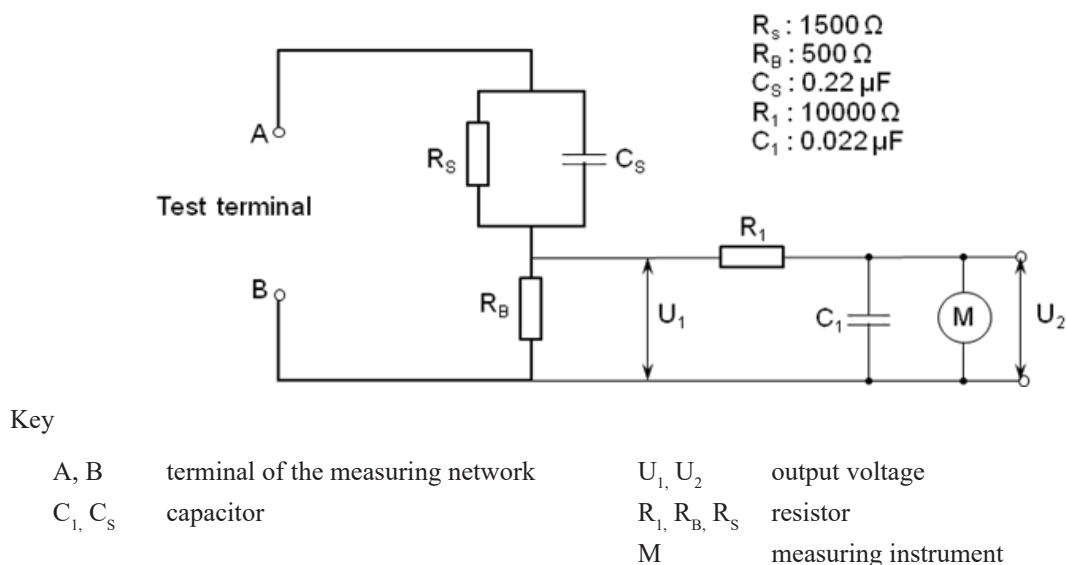


FIG. 14 MEASURING NETWORK OF TOUCH CURRENT WEIGHTED FOR PERCEPTION OR REACTION

A caution symbol  shall be placed on the outside of the d.c. electric vehicle supply equipment, visible to the user.

The minimum size of the protective earthing conductor shall comply with the local safety regulations, and shall be indicated in the installation manual.

12.7 Dielectric Withstand Voltage

Addition:

12.7.101 Suppression of Transient Overvoltage at Input (Insulation Coordination)

When applying the test setup of IS 17017 (Part 21/Sec 2) : 2019, Annex E, with an impulse voltage according to Table F.1 of IS 15382 (Part 1) : 2014 at the input of the d.c. electric vehicle supply equipment, the d.c. electric vehicle supply equipment shall limit the output voltage to:

- 2 500 V between DC+ and protective earthing conductor;
- 2 500 V between DC– and protective earthing conductor; and
- output voltage of d.c. electric vehicle supply equipment plus 500 V, between DC+ and DC–.

The d.c. electric vehicle supply equipment shall operate at its rated output voltage during the test.

Compliance is checked by applying the test setup of IS 17017 (Part 21/Sec 2) : 2019, Annex E, with a voltage according to Table F.1 of IS 15382 (Part 1) : 2014 at the input of the d.c. electric vehicle supply equipment.

NOTES

1 The overvoltage reduction can be achieved by combination of one or more attenuation means in accordance with 4.3.3.6 of IS 15382 (Part 1) : 2014.

2 For specification of the overvoltage category (OVC) of the primary circuit of the d.c. electric vehicle supply equipment, see 12.3 of IS 17017 (Part 1) : 2018.

12.7.102 Protection against Transient Overvoltages of Atmospheric Origin or due to switching

Any power or data line cable connected to the d.c. electric vehicle supply equipment may be protected against lightning or switching events by the use of appropriate surge protective devices according to IS 16463 series. The test class and the surge/impulse current requirement (I_n and/or I_{imp}) for these devices may be determined according to the IS/IEC 62305-4. The voltage protection level (U_p) for these devices may be determined according to the requirements of IS/IEC 62305-4 : 2010, **B-2.1** in conjunction with the overvoltage categories as specified in **12.3** of IS 17017 (Part 1) : 2018, when applicable.

12.11 Mechanical Strength

Replacement:

For ground mounted and wall mounted d.c. electric vehicle supply equipment in locations with restricted access, the minimum degree of protection against mechanical impact shall be IK07 according to IS 17050 : 2018.

For ground mounted and wall mounted d.c. electric vehicle supply equipment in locations with non-restricted access, the minimum degree of protection against mechanical impact shall be IK08 according to IS 17050 : 2018.

For movable d.c. electric vehicle supply equipment under 18 kg in locations with non-restricted access, the minimum degree of protection against mechanical impact shall be IK08 according to IS 17050 : 2018.

Movable d.c. electric vehicle supply equipment under 18 kg shall comply with 4.4.4.3 of IS/IEC 62368-1 : 2014.

Addition:

12.101 Input Current

The steady state input current of the d.c. electric vehicle supply equipment shall not exceed the rated input current by more than 10 percent under the most onerous charging conditions.

Compliance is checked by measuring the input current of the d.c. electric vehicle supply equipment under the operating point (*see 102.2.4*) which produces the highest value of input current.

Each measurement of the input current shall be taken when the input current has stabilized.

NOTES

1 When the d.c. electric vehicle supply equipment has more than one voltage rating, the input current is measured at each voltage rating;

2 When the d.c. electric vehicle supply equipment has one or more rated voltage ranges, the input current is measured at the extremes of each rated voltage range.

12.102 Specific Requirements for Liquid Cooled d.c. EV Supply Equipment

A d.c. electric vehicle supply equipment employing liquid cooling as an element of the thermal management system shall comply with the additional requirements for liquid cooling according to 4.7.2 of IEC 62477-1 : 2016.

12.103 Power Supply Cords

12.103.1 General

A power supply cord of d.c. electric vehicle supply equipment shall be of the sheathed type.

Rubber sheathed power supply cords shall be of synthetic rubber and not lighter than ordinary

tough rubber sheathed flexible cord according to IEC 60245-1 : 2008, designation 60245 IEC 53.

PVC sheathed power supply cords shall comply with the following:

- a) for equipment provided with a non-detachable power supply cord and having a mass not exceeding 3 kg, be not lighter than light PVC sheathed flexible cord according to IEC 60227-1 : 2007, designation 60227 IEC 52;
- b) for equipment provided with a non-detachable power supply cord and having a mass exceeding 3 kg, be not lighter than ordinary PVC sheathed flexible power supply cord according to IEC 60227-1 : 2007, designation 60227 IEC 53;

NOTE — There is no limit on the mass of the equipment if the equipment is intended for use with a detachable power supply cord.

- c) for equipment provided with a detachable power supply cord, be not lighter than light PVC sheathed flexible cord according to IEC 60227-1 : 2007, designation 60227 IEC 52.

For plug and cable d.c. electric vehicle supply equipment that has protective earthing, a protective earthing conductor shall be included in the supply cord.

Compliance is checked by inspection.

12.103.2 Cross Sectional Area

The supply cords shall have conductors with cross-sectional areas not less than those specified in Table 11.

Table 11 Sizes of Conductors of Power Supply Cord
(Clause 12.103.2)

Rated current of the equipment ^a	Minimum conductor sizes
A up to and including	Cross-sectional area mm ²
3	0.5 ^b
6	0.75
10	1.00 (0.75) ^c
16	1.50 (1.0) ^d
25	2.5
32	4
40	6
63	10
80	16
100	25
125	35
160	50
190	70

Rated current of the equipment ^a	Minimum conductor sizes
A up to and including	Cross-sectional area mm ²
230	95
260	120
300	150
340	185
400	240
460	300
NOTES 1 IEC 60320-1 specifies acceptable combinations of appliance couplers and flexible cords, including those covered by footnotes^b, ^c and^d. However, a number of countries have indicated that they do not accept all of the values listed in this table, particularly those covered by footnotes ^b, ^c and ^d. 2 For higher currents <i>see</i> the IEC 60364 series. ^a The rated current includes currents that can be drawn from a socket outlet providing mains power for other equipment. ^b For rated current up to 3 A, a nominal cross-sectional area of 0.5 mm² may be used in some countries provided that the length of the cord does not exceed 2 m. ^c The value in parentheses applies to detachable power supply cords fitted with the connectors rated 10 A in accordance with IEC 60320-1 (types C13, C15, C15A and C17) provided that the length of the cord does not exceed 2 m. ^d The value in parentheses applies to detachable power supply cords fitted with the connectors rated 16 A in accordance with IEC 60320-1 (types C19, C21 and C23) provided that the length of the cord does not exceed 2 m.	

Compliance is checked by inspection.

12.103.3 Cord Anchorages and Strain Relief for Non-Detachable Power Supply Cords — Cord Strain Relief

12.103.3.1 General

Protective measures against strain being transmitted to the equipment terminations of the conductors of the supply cord are specified below.

A knot shall not be used as a strain relief mechanism.

A screw that bears directly on the cord or cable shall not be used as a strain relief mechanism unless the cord anchorage, including the screw, is made of insulating material and the screw is of comparable size to the diameter of the cord being clamped.

When a pull force and a torque are applied to a non-detachable power supply cord or cable, a basic safeguard shall minimize strain from being transmitted to the cord or cable terminations.

The pull force applied to the cord or cable is specified in Table 12. The force is applied in the most unfavourable direction for 1 s and repeated 25 times.

Table 12 Cord Strain Relief Pull Force
(Clause 12.103.3.1)

Mass of the equipment kg	Force N
Up to and including 1	30
Over 1 up to and including 4	60
Over 4	100

A torque of 0.25 Nm is applied for 1 min to the cord or cable immediately after the pull force application. The torque is applied as close as practicable to the strain relief mechanism and is repeated in the opposite direction.

Compliance is determined by measurement and visual inspection. There shall be no damage to the cord or conductors and the displacement of the conductors shall not exceed 2 mm. Stretching of the cord outer jacket without displacement of the conductors is not considered displacement.

12.103.3.2 Strain relief mechanism failure

If the basic protective measure (strain relief mechanism) should fail and strain is transmitted to the non-detachable power supply cord or cable terminations, a supplementary protective measure shall ensure that the earth termination is the last to take the strain.

Compliance is determined by inspection and, if necessary, by defeating the basic protective measure and inspecting the conductor slack while applying the force in Table 12.

12.103.3.3 Cord sheath or jacket position

The cord or cable sheath or jacket shall extend from the basic safeguard (strain relief mechanism) into the equipment at least one-half the diameter of the cord or cable.

Compliance is checked by inspection.

12.103.3.4 Strain relief and cord anchorage material

The cord anchorage shall either be made of insulating material or have a lining of insulating material complying with the requirements for basic insulation. Where the cord anchorage is a bushing that includes the electrical connection to the screen of a screened power cord, this requirement shall not apply.

If the basic protective means (strain relief mechanism) is made of polymeric material or if the basic protective means is mounted in an enclosure consisting of polymeric material, the basic protective means shall retain its structural properties following the mould stress relief according to **12.104**.

Compliance is determined by inspection and by applying the force and torque tests of **12.103.3.1** after the basic protective means has come to room temperature.

12.104 Stress Relief Test

Stress relief is checked by the mould stress relief test of IEC 60695-10-3 or by the test procedure described below or by the inspection of the construction and the available data where appropriate.

One sample consisting of the complete equipment, or of the complete enclosure together with any supporting framework, is placed in a circulating air oven at a temperature 10 K higher than the maximum temperature observed on the sample during the heating test of **12.108.2.2**, but not less than 70 °C, for a period of 7 h, then cooled to room temperature.

For large equipment where it is impractical to condition a complete enclosure, a portion of the enclosure representative of the complete assembly with regard to thickness and shape, including any mechanical support members, may be used.

NOTE — Relative air humidity need not be maintained at a specific value during this test.

12.105 Abnormal Operation and Simulated Fault Condition Tests

12.105.1 General

Protection against the risk of thermal, electric shock and energy hazards in the case of an abnormal operating or simulated fault condition of d.c. electric vehicle supply equipment shall be evaluated by tests defined in this Clause. Testing may be performed on sub-assemblies while positioned and operated under end use conditions.

Simulated abnormal operating and fault conditions shall be applied one at a time. Faults that are a direct consequence of a simulated fault or abnormal operating condition are considered to be a part of that simulated fault or abnormal operating condition.

Cheese cloth and/or surgical cotton are to be used as indicators for risk of fire. These indicators shall be placed at all openings on the outside of the enclosure in a manner which will not significantly affect cooling.

Where the installation manual requires external means of protection against faults, these specific means shall be provided for the test.

The voltages of accessible SELV circuits as well as accessible earthed and unearthed conductive parts shall be monitored.

The test shall be performed until terminated by activation of a protective device or mechanism (internal or external), a component failure occurs that interrupts the fault condition, temperatures stabilize, or a risk of fire and/or electric shock hazard occurs.

12.105.2 Pass Criteria

As a result of testing, the d.c. electric vehicle supply equipment shall comply with the following:

- a) there shall be no emission of flame, burning particles or molten metal;
- b) the cheese cloth or surgical cotton indicator shall not have ignited;
- c) the earth connection and protective equipotential bonding shall not have opened;
- d) doors and covers shall remain in place;
- e) during and after the test, accessible SELV circuits and accessible conductive parts shall not exhibit voltages exceeding the touch voltages specified in 12.6 of IS 17017 (Part 1);
- f) dielectric withstand voltage test specified in 12.7 of IS 17017 (Part 1);
- g) devices/components used for the mounting of live parts shall not break away from their initial position; and
- h) no conductor shall be pulled out of its terminal conductor.

The d.c. electric vehicle supply equipment is not required to be operational after testing and it is possible that the enclosure can become deformed. Overcurrent protection integral to the d.c. electric vehicle supply equipment, or specified by the installation manual to be used with the equipment is allowed to open.

12.105.3 Output Short-Circuit Test

The d.c. output of the charging cable shall be connected to an appropriate switching means that will not limit the short circuit current.

The equipment under test shall be supplied with mains power and the output shall be connected to an artificial load with a dedicated electric vehicle simulator for each system and operated under rated output conditions prior to closing the switching means that causes the short circuit.

Compliance is checked by application of the pass criteria in 12.105.2. This test is not applicable to System C.

12.105.4 Breakdown of Components Test

12.105.4.1 Load conditions

The breakdown of a component, identified by circuit analysis, shall be tested with the d.c. electric vehicle supply equipment connected to an artificial load with a dedicated electric vehicle simulator for each system at full load or light load whichever creates the more severe condition.

Testing may be conducted using the sub-assembly in which the identified component is located. In this case, the sub-assembly shall be loaded to simulate normal operating conditions.

12.105.4.2 Application of short circuit or Open Circuit

The short circuit shall be applied with test leads of a cross section appropriate for the current that normally flows through the component, but not less than 2.5 mm². Then length of the loop shall be as short as practical to perform the test. Short circuits and open circuits are applied using an appropriate switching device.

Each identified component shall be subjected to only one simulation of breakdown unless both open-and short circuit failure modes are likely in that component.

12.105.4.3 Test sequence

For the breakdown of components test, identified components shall be short circuited or open circuited, whichever creates the worst hazard, one at a time.

Compliance is checked by the application of the pass criteria in 12.105.2. In addition, during and after the application of the short circuit or open circuit, any flame inside the equipment shall extinguish within 10 s and no surrounding parts shall have ignited.

12.105.5 Loss of a.c. Supply Phase Test

A multi-phase d.c. electric vehicle supply equipment shall be operated with each phase (including neutral, if used) disconnected in turn at the supply input. The test shall be performed by disconnecting one phase with the equipment connected to an artificial load with a dedicated electric vehicle simulator for each system operating at maximum rated output. The test is repeated by initially energizing the d.c. electric vehicle supply equipment with one lead disconnected.

The test shall continue until terminated by a protective mechanism, a component failure occurs, or the temperature stabilizes.

Compliance is checked by the application of the pass criteria in 12.105.2.

12.105.6 Inoperative Blower/Fan Motor Test

d.c. electric vehicle supply equipment having forced ventilation shall be connected to an artificial load with a dedicated electric vehicle simulator for each system while operating at maximum rated current and power output with fan or blower motor or motors made inoperative either singly or in combination from a single fault. The fan or blower motor shall be made inoperative by either physically preventing rotation or by disconnecting its power source.

Compliance is checked by the application of the pass criteria in 12.105.2.

12.105.7 Clogged Filter Test

d.c. electric vehicle supply equipment having filtered ventilation openings shall be connected to an artificial

load with a dedicated electric vehicle simulator for each system while operating at maximum rated current and power output with the openings blocked to represent clogged filters. The test shall be performed initially with 50 percent of the ventilation openings surface blocked. The test shall be repeated under a full blocked condition.

Compliance is checked by the application of the pass criteria in **12.105.2**.

12.106 Protection against Electrically Caused Fire

12.106.1 General

The protective measure to reduce the risk of the spread of fire under normal operating conditions and single fault conditions to the environment from within is two-fold:

- a) implementation of a fire enclosure, and
- b) selection of internal combustible parts with a low flammability classification.

NOTE — Normally, abnormal operating and fault condition testing (for example open- and short-circuit of electronic components) would be required to demonstrate the potential risk of fire. However, this protective measure is designed to facilitate the use of low flammability classification internal materials and a fire enclosure (external or internal or a combination of both) to provide containment of fire originating from within.

12.106.2 Fire Enclosure

Fire enclosures are used to reduce the risk of the spread of fire to the environment from within, independent of the location where they are installed. An overall fire enclosure shall be provided for d.c. electric vehicle supply equipment unless internal fire enclosure(s) are provided.

The fire enclosure shall be designed according to 4.6.3 of IEC 62477-1 : 2016. Flammability of fire enclosure materials in d.c. electric vehicle supply equipment shall be according to 4.6.3.2 of IEC 62477-1 : 2016.

For general information on openings of fire enclosures, see 4.6.3.3.1 of IEC 62477-1 : 2016.

Openings in the top surface of the fire enclosure shall be according to 4.6.3.3.2 of IEC 62477-1 : 2016, and the corresponding test shall comply with 5.2.2.2 of IEC 62477-1 : 2016.

Openings in the sides of the fire enclosure shall be according to 4.6.3.3.2 of IEC 62477-1 : 2016.

Openings in the bottom of the fire enclosure shall be according to 4.6.3.3.3 of IEC 62477-1 : 2016.

The flaming oil test shall comply with 5.2.5.6 of IEC 62477-1 : 2016.

Fire enclosure bottom openings for ground mounted d.c. electric vehicle supply equipment in fixed installations shall comply with 6.4.8.3.5 of IEC 62368-1 : 2014.

Doors or covers in fire enclosures shall comply with 4.6.3.3.4 of IEC 62477-1 : 2016.

Materials for components that fill an opening in a fire enclosure shall comply with 4.6.3.2 of IEC 62477-1 : 2016 or with IS/IEC 60695-11-10 flammability requirements for V-1 material.

Provision of internal fire enclosure(s) as the protective measure against the spread of electrically-caused fire leads to consideration of any external combustible parts, for example decorative in function, located outside of the internal fire enclosure and not required as part of the protective measure. These external parts are not required to meet the - 5 VA flammability class requirement and need only have a V-2 minimum classification.

Internal fire enclosure construction and internal combustible material considerations are the same as described.

Combustible materials located within the fire enclosure shall comply with 4.6.2.2 of IEC 62477-1 : 2016.

Compliance is checked by inspection.

12.107 Protection against Chemical Hazards

12.107.1 Type of Coolant

The liquid coolant utilized shall be non-hazardous to the environment according to the Globally Harmonized System for the Classification and Labelling of Chemicals. The biodegradability of the liquid coolant shall be ≥ 60 percent tested according to OECD 301 B and stated into the data sheet.

Warnings shall be provided in the installation manual or data sheet indicating that leaking or material degradation shall occur if a coolant other than that specified by the manufacturer is used.

Compliance is checked by inspection.

12.107.2 Environmental Considerations

The liquid coolant utilized shall be non-hazardous in accordance with local regulations. The liquid coolant shall be non-hazardous for the environment or shall be used in a manner such that any spills are contained within the equipment and isolated against the environment in accordance to the local regulations.

Environmental safety data sheet shall be provided for all specified liquid coolant approved the cable assembly manufacturer.

Compliance is checked by inspection.

12.107.3 Flammability

The liquid coolant shall not lead to a fire hazard if leaked onto exposed electrical parts. The minimum flashpoint of the liquid coolant shall be 135 °C.

Compliance is checked by inspection of the material safety data sheets or by the test according to ISO 2719.

12.107.4 Conductivity

The d.c. electric vehicle supply equipment already has protection against electric shock, for example, insulation monitoring device (IMD, System C) or leakage current device (System A). Also, during normal operation, no leakage of coolant is allowed (*see* 12.102). Therefore, no requirements or tests shall be necessary for the conductivity of the liquid coolant.

12.107.5 Material Compatibility

All liquid coolant confining parts of the liquid handling system shall be resistant to the action of the liquid coolant and shall not degrade over time due to the exposure to heat. Non-metallic parts shall be able to maintain their physical properties after being exposed to the liquid coolant and air oven ageing as follows:

Compliance is checked by the tests of 12.107.5.1, 12.107.5.2, and 12.107.5.3.

12.107.5.1 Air oven aging plastic parts and gaskets

Six specimens are aged in an air circulating oven at 121 °C for 7 days and shall maintain the physical properties of tensile strength and elongation. The tensile strength and ultimate elongation shall not be less than 60 % of the tensile strength and ultimate elongation of the as-received sample. The test method of IEC 60811-501 shall be followed.

12.107.5.2 Liquid coolant exposure

Other specimens are to be immersed in the liquid coolant at 80 °C ± 2.0K for 70 ± 0.5 h.

Six samples of each material, 25.4 mm wide and 203 mm long and not thicker than the thinnest part in the application are required for this test. Three are tested as-received and three are tested following immersion.

The tensile strength and ultimate elongation shall not be less than 60 percent of the tensile strength and ultimate elongation of the as-received samples.

12.107.5.3 Creep resistance test

Two samples of each non-metallic part of the liquid coolant confining system shall be conditioned for 14 days at a temperature of 87 °C and placed in a full draft air-circulating oven. Following the conditioning, the parts shall show no sign of deterioration such as cracking and embrittlement.

12.108 Enclosures**12.108.1 General**

Enclosures shall be designed according to 4.12 of IEC 62477-1 : 2012 except for the requirements for IP degrees in 12.4.

12.108.2 Strength of Materials and Parts**12.108.2.1 General**

Strength of materials and parts of d.c. electric vehicle supply equipment shall be according to 10.2 of IEC 61439-7 : 2018.

The d.c. electric vehicle supply equipment shall be constructed of materials capable of withstanding the mechanical, electrical, thermal and environmental stresses that are likely to be encountered in anticipated service conditions.

12.108.2.2 Properties of insulating materials — thermal stability

For enclosures or parts of enclosures made of insulating materials, thermal stability shall be verified by the dry heat test.

Compliance is checked by inspection and test in accordance with 10.2.3.1 of IEC 61439-1.

12.108.2.3 Properties of insulating materials — resistance to heat and fire

Resistance of insulating materials to heat and fire shall be according to 8.1.3.2 of IEC 61439-1 : 2011.

Compliance is checked by inspection of manufacturer's test data or test.

12.108.3 Enclosure Integrity Tests

The enclosure integrity tests shall be according to 5.2.2.4 of IEC 62477-1 : 2016.

NOTE — The enclosure integrity tests specified in IEC 62477-1 : 2012 include the tests for deflection, steady force, impact, drop, stress relief, stability, wall or ceiling mounted equipment, handles, and manual controls securement test.

12.109 Components Bridging Insulation**12.109.1 General**

Components bridging insulation shall comply with the requirements of the level of insulation, for example basic, reinforced or double, they are bridging.

12.109.2 Isolating Transformers

Isolating transformers, excluding safety isolating transformers used for signalling, shall comply with the requirements of G.5.3 of IEC 62368-1 : 2014 or IEC 61558-1 and IEC 61558-2-4.

Compliance is checked by inspection.

12.109.3 Capacitors

Capacitors bridging isolation barriers shall comply with ISO/QC 302400.

13 OVERLOAD AND SHORT CIRCUIT PROTECTION

This clause of IS 17017 (Part 1) is applicable except as follows:

Replacement:

13.2 Overload Protection of the Cable Assembly

Not applicable.

13.3 Short-Circuit Protection of the Charging Cable

Not applicable.

Addition:

13.101 Short-Circuit Protection of the d.c. Connection

For a short-circuit supplied by the d.c. electric vehicle supply equipment, the d.c. electric vehicle supply equipment shall fulfil all of the following requirements:

- a) limit the peak current, including transient effects, to:
 - 1) 30 kA or less at the contacts of the vehicle connector without short-circuit protection device, and 10 kA (or less) at the contacts of the vehicle connector equipped with short-circuit protection device for System A; and
 - 2) 10 kA or less at the contacts of the vehicle connector for System C.
- b) limit the I^2t value to:
 - 1) 400 000 A²s or less at the contacts of the vehicle connector for System A; and
 - 2) 1 000 000 A²s or less at the contacts of the vehicle connector for System C.
- c) trigger an
 - 1) error shutdown within 1 s after the detection of the short-circuit condition for System A; and
 - 2) emergency shutdown within 1 s after the start of the short-circuit condition for System C.
- d) disable its d.c. output until the d.c. electric vehicle supply equipment has been inspected and repaired, if needed.
- e) The power supply circuit of the d.c. electric vehicle supply equipment shall have a short-circuit current withstand rating (I^2t) according to the values as specified in ISO DIS 17409:2019 for the different systems. The minimum cross-sectional area of the line conductors shall be calculated according to Equation (3) of IS 732 : 2019.
- f) An overcurrent protection device shall be provided in the power supply circuit of the d.c. electric vehicle supply equipment. The overcurrent protection device shall withstand a peak current according to the values as specified in

ISO 17409 : 2020 for the different systems. The section of the power supply circuit which is protected by this protection device shall be designed according to the characteristics of this over-current protection device. The section of the power supply circuit which is not protected by this over-current protection device shall comply with requirement e).

For System A the compliance is demonstrated by design review.

For System C, the compliance is tested according to **B-9.3.18**.

For a short-circuit supplied by the electric vehicle the requirements in e) or f) shall be fulfilled.

If the short-circuit current supplied by the d.c. electric vehicle supply equipment is not sufficient to trip a fuse, if any, within the required time to limit the I^2t value, the d.c. electric vehicle supply equipment shall provide an alternative means to interrupt the short-circuit current.

NOTE — The current peak is a result of the discharge of the capacitance of the d.c. electric vehicle supply equipment. The capacitive discharge is a transient phenomenon in the range of milliseconds.

14 AUTOMATIC RECLOSING OF PROTECTIVE DEVICES

This clause of IS 17017 (Part 1) is not applicable except for plug and cable connected d.c. electric vehicle supply equipment.

15 EMERGENCY SWITCHING OR DISCONNECT (OPTIONAL)

This clause of IS 17017 (Part 1) is applicable.

16 MARKING AND INSTRUCTIONS

This clause of IS 17017 (Part 1) is applicable except as follows:

16.1 Installation Manual of EV Charging Stations

Addition:

For system A, not applicable.

For Systems C,

- a) If coolant is used, for example for thermal management system, the installation manual of the d.c. electric vehicle supply equipment shall include information about the coolant properties according to **101.2** of IEC TS 62196-3-1.
- b) A standard sign “Refer to instruction manual” according to ISO 7010 shall be visibly attached to the thermal exchange; and
- c) The name of the coolant shall be visible attached at the enclosure of the cooling unit.

Compliance is checked by inspection.

For d.c. electric vehicle supply equipments intended for fixed installation, the installation manual shall include information about the protective measure to be provided by the installations. If under normal and fault conditions any resulting d.c. component of the current in the protective conductor may exceed 6 mA, a caution notice and the symbol W001 of IS 16451 shall be provided in the installation manual, and the symbol shall be placed on the product. The caution notice shall be

“CAUTION: This product can cause a d.c. current in the protective conductor. Where a residual current-operated protective device (RCD) is used for protection against electrical shock, only an RCD of Type B is allowed on the supply side of this product.” or equivalent (see also, 6.3.7.5 and 4.4.8 of IEC 62477-1: 2016).



NOTE — Symbol denotes caution, please refer to documentation.

The manufacturer shall recommend a preventative maintenance program for the replacement of the cable assembly following, for example, a predetermined period of time in service and/or number of charging sessions.

Compliance is checked by inspection of the program established by the manufacturer.

16.4 Marking of Charging Cable Assemblies Case B
Not applicable.

Addition:

101 SPECIFIC REQUIREMENTS FOR D.C. EV SUPPLY EQUIPMENT

101.1 Protection Against Uncontrolled Reverse Power Flow from Vehicle

The d.c. electric vehicle supply equipment shall be equipped with a protective means against the uncontrolled reverse power flow from vehicle. Uncontrolled power flow does not include instantaneous reverse power flow, which may occur with closing of contactors within the tolerances and duration specified in A-3.9, A-6.2.8 and B-6.2.

101.2 Specific Requirements for Isolated Systems

101.2.1 Operating Ranges for Output Voltage, Output Current, and Output Power

The manufacturer of the d.c. electric vehicle supply equipment shall specify the operating range using the following parameters, and indicate them in the user manual and the installation manual:

- output voltage range $[V_{\min}, V_{\max}]$;
- output current range $[I_{\min}, I_{\max}]$;
- maximum output power $P_{\max}$;
- ambient operating temperature range; and
- maximum operating altitude above sea level.

NOTE — IS 17017 (Part 24) specifies which of these parameters shall be communicated to the electric vehicle using digital communication, and how this is carried out.

The ambient operating temperature range shall at least cover the range from -5°C to $+55^{\circ}\text{C}$.

The maximum operating altitude above sea level shall not be less than 1 000 m above sea level.

The manufacturer of the d.c. electric vehicle supply equipment may specify one or more additional operating ranges of the d.c. electric vehicle supply equipment by specifying:

- an ambient operating temperature range wider than the one referred to above, and/or
- a maximum operating altitude above sea level higher than the one referred to above.

In such a case, the other parameter ranges applicable for those/this additional operating range(s) may deviate from the ones referred to above, for example for example

- an output voltage range smaller than the one referred to above, and/or
- an output current range smaller than the one referred to above, and/or
- a maximum output power smaller than the one referred to above.

The d.c. electric vehicle supply equipment shall be able to provide electrical energy with an output quality as specified in 101.2.2 within each operating range specified in such a way, in particular with the output voltage request from the electric vehicle being in the range $[V_{\min}, V_{\max}]$ and the output current request from the electric vehicle being in the range $[I_{\min}, I_{\max}]$, and the output power not exceeding $P_{\max}$.

The d.c. electric vehicle supply equipment shall not exceed its specified maximum output power, even if the power requested by the electric vehicle is beyond the maximum output power of d.c. electric vehicle supply equipment.

The d.c. electric vehicle supply equipment may also be able to operate below the lower limit of a specified operating range, that is provide output current less than given by $I_{\min}$ or output voltage less than given by $V_{\min}$, without the need to fulfil all requirements given in 101.2.

101.2.2 Output Voltage and Current Tolerance**101.2.2.1 Output current regulation in CCC**

Requirements for output current regulation in CCC are specified in **A-3.10** and **B-6.4**.

Compliance for System A is checked by the following test. Compliance for System C is checked by **B-9.3.12**.

The test shall be performed according to the following procedure:

- Connect the d.c. electric vehicle supply equipment to an artificial load with a dedicated electric vehicle simulator appropriate for the system. The setup of the test load for each system is shown in Table 26
- Measure the voltage ($V_{EVSE\ output}$) and current ($I_{EVSE\ output}$) of the power line continuously.
- Start charging with the procedure specified by charger manufacturer.
- Record current command value $I_{EV\ target}$ and $I_{EVSE\ output}$ at the operating points as specified in Annex A. For operating point, see **102.2.4**. $I_{EV\ target}$ is the output current requested by the test load, which is sent to the d.c. electric vehicle supply equipment via digital communication.

During the voltage/current sweep (transition from one OP to another) and for each operating point, check that the difference between the measured current values and

the required value sent by the electric vehicle simulator are within the limits specified in **101.2.2.1**.

101.2.2.2 Output voltage regulation in CVC

For CVC, the maximum voltage deviation during pre-charge state and during charging of the vehicle/traction battery shall not exceed ± 5 percent of the requested voltage, or ± 2 percent of the maximum rated voltage of the d.c. electric vehicle supply equipment, whichever deviation is smaller (see Fig. 15).

These requirements are for System C.

Compliance is checked by the tests in **B-9.3.13**.

NOTES

1 The current ripple is not specified within the CVC mode as it depends on the impedance between the d.c. output and the electric vehicle battery, which is not defined in ISO 17409.

2 The current requirements of CCC mode like regulation (see **101.2.2.1**) and control delay (see **101.2.3**) are not applicable in CVC mode, which leads to undefined current behaviour within the CVC mode.

The electric vehicle can prevent the d.c. electric vehicle supply equipment from unintentionally entering the CVC mode during charging as this can lead to large current ripples when the battery is attached or it can lead to no current if the requested voltage minus the voltage deviation is below the battery voltage. When the electric vehicle battery is attached to the d.c. output, the CVC mode can be avoided by requesting a voltage of at least $V_{Compensation}$ above the battery voltage.

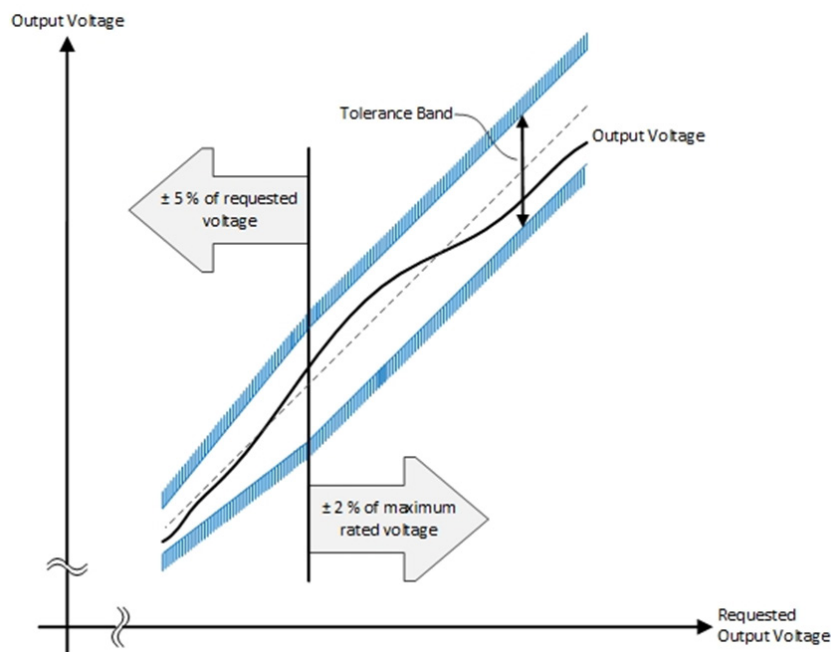


FIG. 15 VOLTAGE TOLERANCES

$$V_{EV\ target} > V_{Compensation} + V_{Battery}$$

$$V_{Compensation} = V_{Deviation} + V_{rip} + V_{EV\_drop} + V_{Margin}$$

$$V_{Deviation} = \min(2\ \text{percent} \times V_{Rated}, 5\ \text{percent} \times V_{EV\ target})$$

$$V_{rip} = \max(5\ \text{V}, 1\ \text{percent} \times V_{EV\ target})$$

$$V_{EV\_drop} = I_{Output} \times Z_{EV}(I_{Output})$$

where

$V_{EV\ target}$	is the voltage request coming from the electric vehicle
$V_{Compensation}$	is the voltage the electric vehicle should add to prevent CVC mode
$V_{Battery}$	is the voltage of the electric vehicle battery
$V_{Deviation}$	is the deviation on the output voltage
V_{rip}	is the ripple on the d.c. output
V_{EV_drop}	is the voltage drop between the d.c. output and the vehicle battery
V_{Margin}	is a voltage margin chosen by the electric vehicle manufacturer
V_{Rated}	is the rated output voltage of the d.c. electric vehicle supply equipment
I_{Output}	is the d.c. output current of the d.c. electric vehicle supply equipment
$Z_{EV}(I_{Output})$	is the impedance of the electric vehicle at the d.c. output current

$V_{Deviation} + V_{rip}$ is 30 V at 1000 V.

101.2.3 Control delay of charging current in CCC

The d.c. electric vehicle supply equipment shall control the output current within 1 s after acknowledging reception of the request from the vehicle according to IS 17017 (Part 24), with a current control accuracy specified in 101.2.2.1, and with a changing rate dI_{min} of 20 A/s or more.

If the vehicle requests a target current I_N , which shows deviation lower than or equal to 20 A compared to the base current value I_0 , the output current of d.c. electric vehicle supply equipment shall be within the tolerance limits given in 101.2.2.1 within a delay time of 1 s after acknowledging reception of the request from the vehicle according to IS 17017 (Part 24).

If the vehicle requests any target current I_N , which shows deviation higher than 20 A compared to the base current value I_0 , the output current of d.c. electric vehicle supply equipment shall be within the tolerance limits given in 101.2.2.1 within a delay time T_d as defined in Formula (4), and as shown in Fig. 16.

$$T_d \leq \frac{|I_N - I_0|}{dI_{min}} \text{ for } |I_N - I_0| \geq 20\text{ A} \quad (4)$$

where

T_d is the control delay of charging current;

I_N is the value for the target current;

I_0 is the value for the base current, that is output current at the time of new request;

dI_{min} is the minimum current change rate.

$|I_N - I_0|$ gives the absolute value of the difference between I_N and I_0 .

Compliance for System A is checked by the following test. For system C, see B-9.3.14.

- The d.c. electric vehicle supply equipment is connected to an artificial load with a dedicated electric vehicle simulator appropriate for the system, and operating in CCC mode.
- The time of the electric vehicle simulator sending the output current command shall be recorded, and the actual value of output current in a certain period of time shall be also recorded.

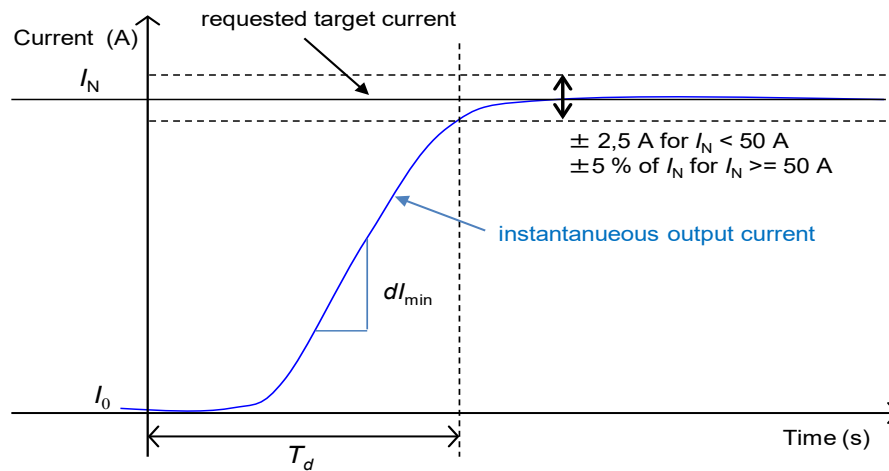


FIG. 16 STEP RESPONSE FOR CONSTANT VALUE CONTROL

- c) The vehicle requests a target current
 - 1) deviation lower than or equal to 20 A; and
 - 2) deviation higher than 20 A.
- d) For System A, change the operating point (see Fig. 27) from
 - 1) OP1 to OP3, OP4, OP5, OP6;
 - 2) OP2 to OP3, OP4, OP5, OP6;
 - 3) OP3, OP4, OP5, OP6 to OP1; and
 - 4) OP3, OP4, OP5, OP6 to OP2.
- e) The d.c. electric vehicle supply equipment shall control the output current,
 - 1) within 1 s after the request; and
 - 2) within a delay time T_d as defined in Formula (4), and as shown in Fig. 16.

101.2.4 Descending Rate of Charging Current

The descending rates for error shutdown and emergency shutdown shall be according to **A-3.8.2** and **A-5** for System A, and **B-3.4** and **B-3.5** for System C.

Compliance for System A is checked by the following test. For System C, see **B-9.3.15**.

This test shall simulate the stop charge command from electric vehicle, to detect the actual output current changes of d.c. electric vehicle supply equipment during the normal charging process.

The test shall be performed according to the following procedure:

- a) The d.c. electric vehicle supply equipment is connected to the vehicle control simulator or artificial load, and operating in CCC mode.
- b) The time of the vehicle control simulator sending the output current command shall be recorded, and the actual value of output current in a certain period of time shall be also recorded.
- c) For normal operation
 - for System A, change the operating point from OP1, OP2, OP3, OP4, OP5 and OP6 to current < 5A
- d) For error shutdown, perform the emergency shutdown from OP1, OP2, OP3, OP4, OP5 and OP6 (for System A)
- e) Check that the system specific requirements for error or emergency shutdown test are met.

101.2.5 Periodic and Random Deviation Current Ripple

Current ripple of d.c. electric vehicle supply equipment during current regulation shall not exceed the limit as defined in Table 13. Measurement shall be made at maximum rated power and rated current, or in the

worst case where the output voltage and output current correspond theoretically to the maximum current ripple. The current ripple is not included in the tolerance defined in **101.2.2.1**.

The artificial load according to Fig. 26 shall be used.

Table 13 Current Ripple Limit of d.c. EV Supply equipment

(Clause 101.2.5)

Limit ^a	Frequency
1.5 App	frequency band above 0 Hz and below 10 Hz
6 App	frequency band above 0 Hz and below 5 kHz
9 App	frequency band above 0 Hz and below 150 kHz
^a difference between positive peak top and negative peak top at full scale output NOTE — The upper value of each frequency band (10 Hz, 5 kHz and 150 kHz) is the cut-off frequency (–3.0 dB) of first order low-pass filter.	

Compliance for System A is checked by the following test. Compliance for System C is checked by **B-9.3.12**.

The d.c. electric vehicle supply equipment is connected to an artificial load and a designated smoothing capacitor.

The d.c. electric vehicle supply equipment shall operate at proper operating points for the test (see Fig. 27).

Measure the current ripple of each frequency bands specified in Table 13.

See **A-3.11** for specific test condition for system A,

101.2.6 Periodic and Random Deviation (Voltage Ripple in CVC)

For requested output voltage up to 500 V, the maximum voltage ripple in normal operation and precharge, if applicable, shall not exceed ± 5 V.

For requested output voltage above 500 V, the maximum voltage ripple in normal operation and precharge, if applicable, shall not exceed ± 1 percent of the requested output voltage.

The maximum voltage slew rate in normal operation shall not exceed ± 20 V/ms.

For explanation of terms, see Fig. 17

Compliance is checked by the test in **B-9.3.13**.

For CVC, when the vehicle battery is not connected: under consideration.

101.2.7 Load Dump

If the vehicle contactors open while the vehicle is being charged at the maximum current of the d.c. electric vehicle supply equipment, the output voltage shall not exceed the limit specified for each system in **A-3.12** or **B-6.2**.

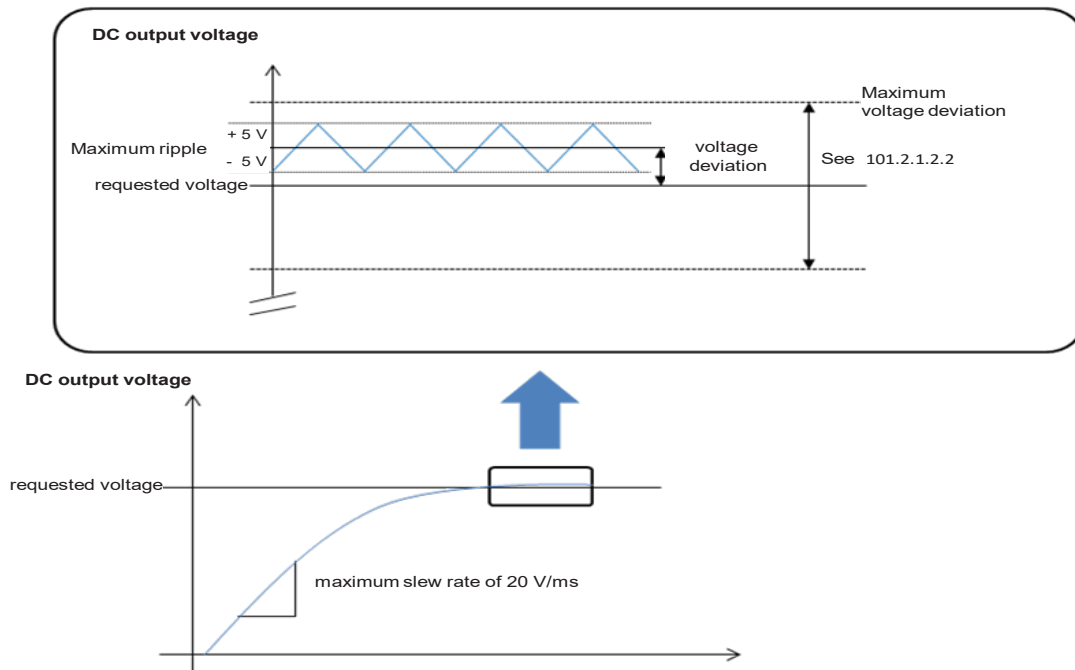


FIG.17 MAXIMUM RATINGS FOR VOLTAGE DYNAMICS

Maximum slew rate of output voltage in case of load dump shall not exceed 250 V/ms.

Compliance for System A is checked by the following test. Compliance for System C is checked by **B-9.3.9**.

Refer to Fig. 26 for the setup of artificial load.

The test shall be performed according to the following procedure:

- Connect the d.c. electric vehicle supply equipment to artificial load.
- Measure the voltage ($V_{EVSE\ output}$) of the power line continuously.
- Start charging with the procedure specified by charger manufacturer.
- Confirm that the d.c. power line between d.c. electric vehicle supply equipment and electric vehicle is energized at the rated voltage, and the d.c. electric vehicle supply equipment is operating at the operating point OP4 in Fig. 27.
- Simulate the disconnection of the vehicle battery by opening S0.
- Check that the d.c. electric vehicle supply equipment terminates the charging process and transfers to shutdown stage, displaying a relevant alarm or error information, if any.
- For each system, check the parameters in Table 14.

Table 14 Parameter for Load Dump Test

(Clause 101.2.7)

Parameter	Requirement through 4) to 6)
	System A
The maximum voltage of $V_{EVSE\ output}$	see Table 29
The maximum slew rate $dV_{EVSE\ output}/dt$	$\leq 250\ V/ms$

101.3 Specific Requirement for Multiple d.c. Outputs

The specific requirements for the multiple d.c. outputs are provided in Annex E.

101.4 Specific Requirement for Charging with Thermal Management System

This clause is applicable for System A and System C.

For charging with thermal management system, the d.c. electric vehicle supply equipment shall be equipped with a cable assembly according to IEC TS 62196-3-1.

101.4.1 Temperature Limits and Self-Diagnostics

101.4.1.1 Temperature of the d.c. contact assembly of the vehicle connector

The d.c. electric vehicle supply equipment shall ensure that the temperature of the d.c. contact assembly of

the vehicle connector complies with the following requirements under the operating ambient temperature up to 55 °C.

- a) The absolute temperature of the d.c. contact assembly shall not exceed 90 °C;
- b) The surface temperature of the cable assembly shall not exceed the temperature limits according to 16.5 of IS 17017 (Part 2/Sec 1); and
- c) If a thermal sensing providing temperature values is implemented in the attached vehicle connector, the d.c. electric vehicle supply equipment shall evaluate the measured values of the thermal sensing device at each d.c. contact assembly.

101.4.1.2 Requirements for self-diagnostics function for thermal management system

The d.c. electric vehicle supply equipment manufacturer shall provide a FMEA according to IEC 60812.

The d.c. electric vehicle supply equipment shall provide appropriate means to reduce the likelihood of a hazard occurring in case of a first fault in the thermal management system, for example, by double or reinforced insulation, flow rate, pressure, temperature, level of coolant, etc.

In case of a thermal exchange device or thermal transport device failure (for example failure of cooling pump, jammed cooling hose), the d.c. electric vehicle supply equipment shall either stop operation or reduce the available current to value for operation without thermal exchange and/or thermal transport, if such a value is given by the cable assembly manufacturer. The d.c. electric vehicle supply equipment shall transmit it to vehicle via digital communication.

In case of a thermal sensing fault, *see* **101.4.2.3**.

Compliance is checked by inspection and test in **101.4.3.4**.

101.4.2 Temperature Monitoring

101.4.2.1 General

The d.c. electric vehicle supply equipment, using cable assembly providing thermal sensing data, shall have measures to continually monitor the provided temperature data.

The d.c. electric vehicle supply equipment shall continually monitor the temperature data of the d.c. contact assemblies during the complete charging sequence.

101.4.2.2 Overtemperature handling

If the measured temperature at one or both d.c. contact assemblies exceeds 90 °C, the d.c. electric vehicle supply equipment shall trigger an error shutdown sequence within 9 s according to **A-4.3.5** for System A and **B-3.4** for System C.

Compliance is checked by test in **101.4.3.3**.

If three consecutive error shutdowns occur due to temperature exceeding 90 °C at one or both d.c. contacts, the d.c. electric vehicle supply equipment shall not start a new supply process until serviced.

Compliance is checked by inspection and measurement.

101.4.2.3 Check of the plausibility of the values provided by the thermal sensing devices

A plausibility check of the thermal sensing devices of the vehicle connector shall be done prior to each charging session. If the plausibility check fails, the d.c. electric vehicle supply equipment shall:

- a) only operate under the current assigned by the manufacturer of the cable assembly for operation without thermal exchange and/or thermal transport;
- b) not start a new supply process until serviced (for System C only).

Compliance is checked by inspection and test in **101.4.3.6**.

If the thermal sensing of a d.c. contact assembly sends no or an implausible signal during charging, the d.c. electric vehicle supply equipment shall:

- a) reduce output current to the current assigned by the manufacturer of the cable assembly for operation without thermal exchange and/or thermal transport or trigger an error shutdown according to **A-3.8.1** within 9 s after the occurrence of the fault;
- b) trigger an error shutdown according to **B-3.4** within 9 s after the occurrence of the fault.

Compliance is checked by inspection and test in **101.4.3.7**.

101.4.3 Tests for Thermal Management System Performance of the d.c. EV Supply Equipment

101.4.3.1 General

For all tests, thermal stabilisation is considered to have occurred when three successive readings, taken at intervals not less than 10 min, indicate no increase greater than 2 K.

The test current is the rated current according to the device under test (DUT) manufacturer's data sheet, if not stated otherwise.

The DUT for these tests is the d.c. electric vehicle supply equipment.

A system specific vehicle simulator equipped with a current sink shall be used for all tests in this Clause.

Each test shall be performed with a corresponding test accessory, called reference device (RD), which mates with the vehicle connector.

The material for all reference devices shall be Cu-ETP.

For System A, all tests, except the test of overtemperature handling according to **101.4.3.3**, shall

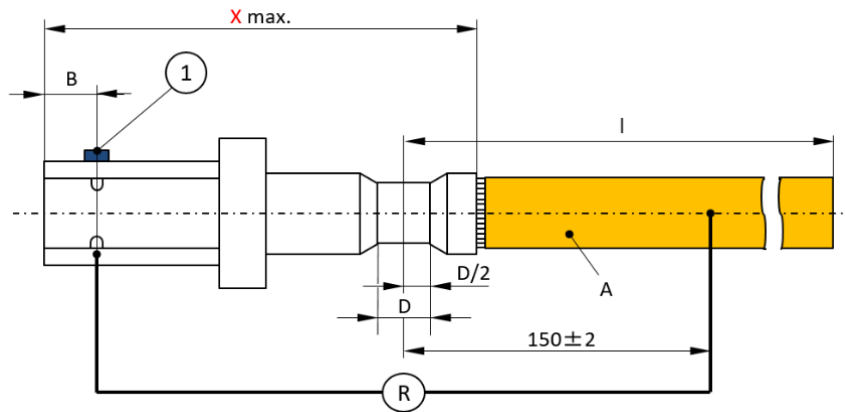
be performed with a RD according to Figure 18 and a test arrangement according to Fig. 19. The test for overtemperature handling according to **101.4.3.3** shall be performed with a RD according to Fig. 20 and a test arrangement according to Fig. 21.

For System C, all tests, except the test of overtemperature handling according to **101.4.3.3**, shall be performed with a RD according to Fig. 22 and a test arrangement according to Fig. 23. The test for overtemperature handling according to **101.4.3.3** shall be performed

with a RD according to Fig. 124 and a test arrangement according to Fig. 26.

The contact resistances of the reference devices, including d.c. contact, contact body, mechanical joining and 150 mm of the attached conductor, measured by four-terminal sensing according to Fig. 18 and Fig. 22 shall comply with the values indicated in Table 15.

Values for wiring cross section and cable length are specified in Table 15.

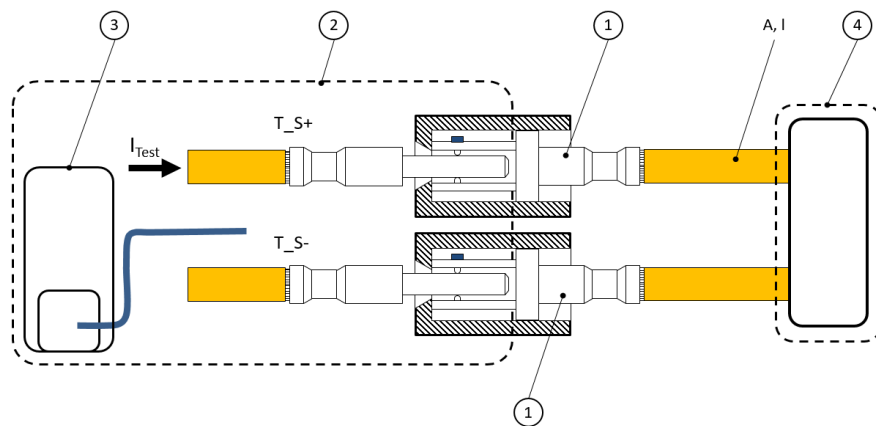


Key

- ① Reference temperature sensor
- A Conductor cross-section (depending on the test current, *see* Table 15)
- B To be determined by the manufacturer
- D To be determined by the manufacturer
- l Length of attached conductor (*see* Table 15)
- R Resistance measurement (*see* Table 15 for values)

NOTE—For missing dimensions, *see* Standard sheet 3-Ia of IS 17017 (Part 2/Sec 3) : 2020.

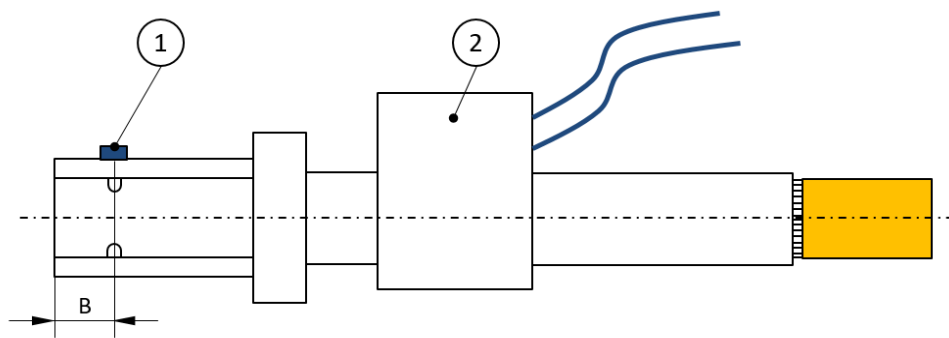
FIG. 18 REFERENCE DEVICE A_0



Key

- ① Reference device A_0
- ② DUT
- ③ d.c. electric vehicle supply equipment with thermal exchange and thermal transfer, if any
- ④ Vehicle simulator with current sink
- A Conductor cross-section (depending on the test current, *see* Table 15)
- l Length of attached conductor (*see* Table 15)
- I_{Test} Test current
- T_S +, T_S - Thermal sensing device inside vehicle connector at DC + and DC -

FIG. 19 TEST ARRANGEMENT A_0

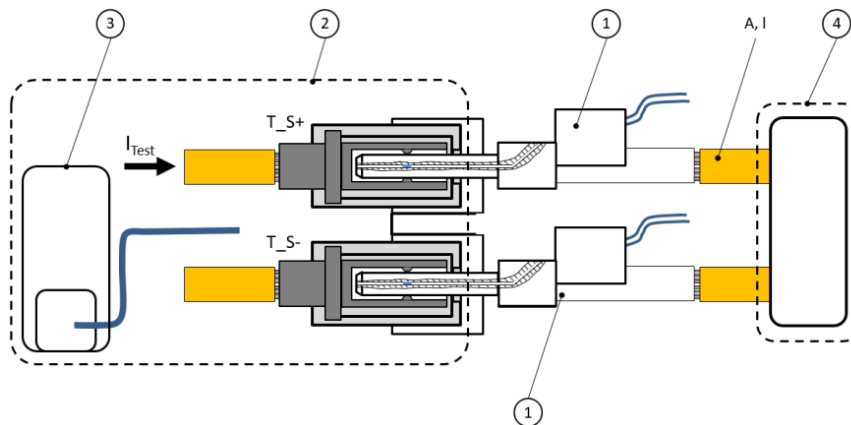


Key

- ① Reference temperature sensor
- ② Heating unit
- B To be determined by the manufacturer

NOTE For missing dimensions, *see* standard sheet 3-Ia of IS 17017 (Part 2/Sec 3) : 2020.

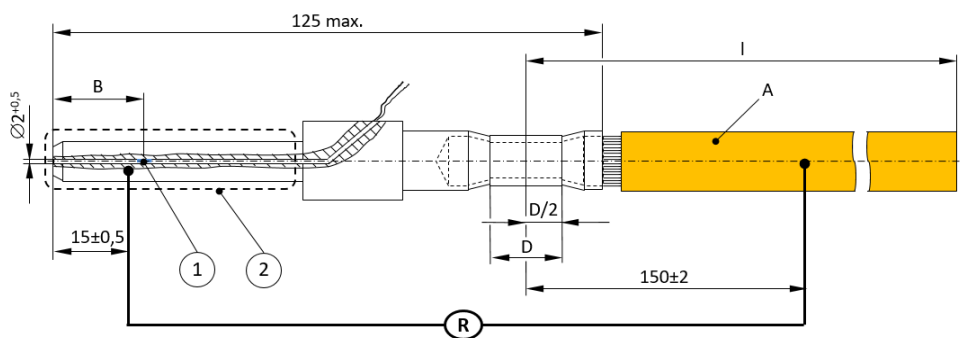
FIG. 20 REFERENCE DEVICE A_1



Key

- ① Reference device A_1
- ② Device under test (DUT)
- ③ d.c. electric vehicle supply equipment with thermal exchange and thermal transfer – if any
- ④ Vehicle simulator with current sink
- A Conductor cross-section (depending on the test current, *see* Table 15)
- l Length of attached conductor (*see* Table 15)
- I_{Test} Test current
- T_{S+}, T_{S-} Thermal sensing device inside vehicle connector at DC + and DC –

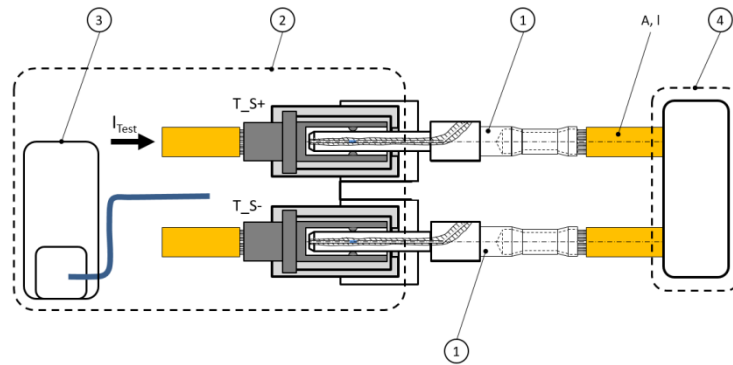
FIG. 21 TEST ARRANGEMENT A_1



Key

- ① Reference temperature sensor
- ② d.c. power contact according to standard sheet 3-IVa (configuration FF) of IS 17017 (Part 2/Sec 3).
- A Conductor cross-section (depending on the test current, *see* Table 15)
- B 18 ± 1 mm for configuration FF
- D To be determined by the manufacturer
- l Length of attached conductor (*see* Table 15)
- R Resistance measurement (*see* Table 15 for values)

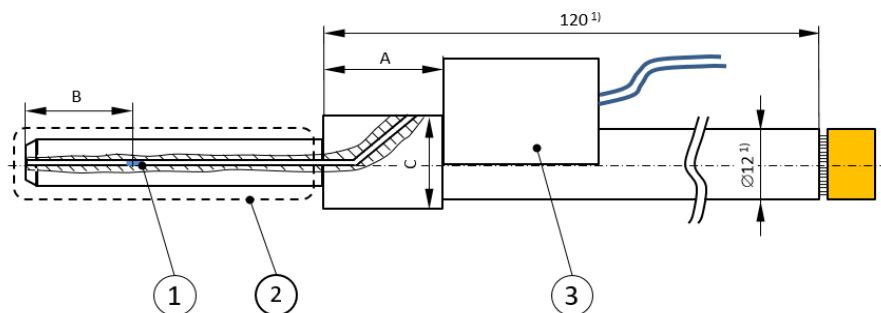
FIG. 22 REFERENCE DEVICE C_0



Key

- ① Reference device C_0
- ② DUT
- ③ d.c. electric vehicle supply equipment with thermal exchange and thermal transfer, if any
- ④ Vehicle simulator with current sink
- A Conductor cross-section (depending on the test current, *see* Table 15)
- l Length of attached conductor (*see* Table 15)
- I_{Test} Test current
- T_S +, T_S – Thermal sensing device inside vehicle connector at DC + and DC –

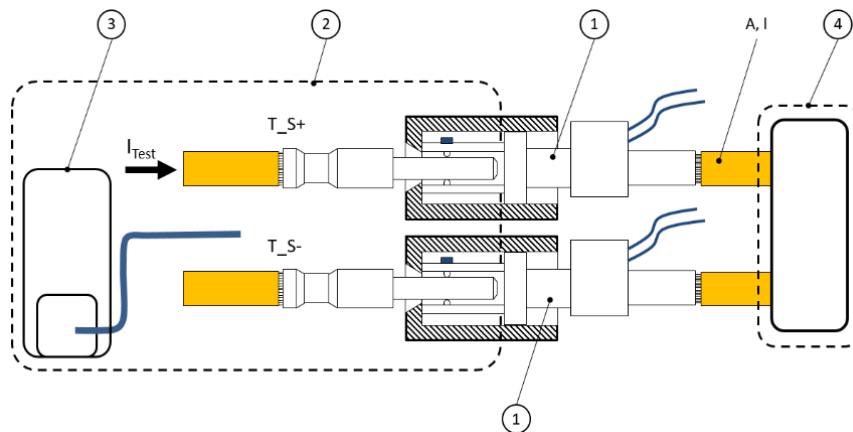
FIG. 23 TEST ARRANGEMENT C_0



Key

- ① Reference temperature sensor
 - ② d.c. power contact according to standard sheet 3-IVa (configuration FF) of IS 17017 (Part 2/Sec 3) : 2020.
 - ③ Heating unit
 - A To be determined by the manufacturer
 - B 18 ± 1 mm for configuration FF
 - C To be determined by the manufacturer
- ¹⁾ The diameter and length of termination (Ø12 and 120) are recommended values.

FIG. 24 REFERENCE DEVICE C_1



Key

- ① Reference device C_0
- ② DUT
- ③ d.c. electric vehicle supply equipment with thermal exchange and thermal transfer, if any
- ④ Vehicle simulator with current sink
- A Conductor cross-section (depending on the test current, *see* Table 15)
- l Length of attached conductor (*see* Table 15)
- I_{Test} Test current
- T_{S+} , T_{S-} Thermal sensing device inside vehicle connector at DC + and DC –

FIG. 25 TEST ARRANGEMENT C_1

Table 15 Values for Parameter A, l and R
(Clause 101.4.3.1)

Parameter	Description	Value	Rated current [A max]			Resistance [$\mu\Omega$]	
			System A		System C	System A	System C
			Non-cooled DUT	Cooled DUT			
A	Conductor cross section	35 mm ²	125 (<i>under consideration</i>)	150	100	(<i>under consideration</i>)	(<i>under consideration</i>)
		50 mm ²	150 (<i>under consideration</i>)	200	200	(<i>under consideration</i>)	123-128
		60 mm ²	–	–	250	(<i>under consideration</i>)	91-96
		70 mm ²	200 (<i>under consideration</i>)	300	300		
		95 mm ²	300 (<i>under consideration</i>)	400	400	(<i>under consideration</i>)	65-70
		120 mm ²	350	–	500	(<i>under consideration</i>)	57-62
		150 mm ²	400	–	–	(<i>under consideration</i>)	
l	Cable length	2 m					

101.4.3.2 Thermal management system performance test

This test is applicable for d.c. electric vehicle supply equipments according to System A and System C using a thermal management system.

For System A, the test is performed with a RD according to Fig. 18 and a test arrangement according to Fig. 19.

For System C, the test is performed with a RD according to Fig. 22 and a test arrangement according to Fig. 23.

The DUT shall be stored for at least 2 h at $(55 \pm 4)^\circ\text{C}$.

The test shall be executed at rated current and may be executed at the minimum output voltage of the DUT.

Once thermal stabilisation has been reached, the DUT shall be operated at rated current and may be operated at the minimum output voltage for an additional 60 min.

Then the current shall be reduced to less than 2 A.

The temperatures measured by the reference temperature sensors of the reference devices shall be monitored with one or more samples per second throughout the test.

This test is passed, if:

- the d.c. electric vehicle supply equipment performs the supply process without any errors, and
- the measured temperatures by the reference temperature sensors do not exceed 90°C , and
- the temperature limits according to 16.5 of IS 17017 (Part 2/Sec 1) : 2020 are not exceeded at any touchable and graspable surface of the DUT (for system C only) or the temperature limits according to **A-9.1** are not exceeded (for system A only).

101.4.3.3 Tests of overtemperature handling

This test is applicable for d.c. electric vehicle supply equipment according to system A using thermal management system and according to system C.

For System A, the test is performed with a RD according to Fig. 20 and a test arrangement according to Fig. 21.

For System C, the test is performed with a RD according to Fig. 24 and a test arrangement according to Fig. 25.

The DUT shall be stored for at least 2 h at $55 \pm 4^\circ\text{C}$

The test shall be executed at rated current and may be executed at the minimum output voltage of the DUT.

The test shall be executed as follows:

- Once thermal stabilization has been reached, the over-temperature of the vehicle connector is stimulated by applying heat power ensuring a constant temperature rise of $2.5 \pm 0.5^\circ\text{C}/\text{min}$ (measured by the reference temperature sensor) on the DC+ contact.
- The test shall be stopped if the temperature as measured by the reference temperature sensor reaches 95°C .

- The test shall be repeated with applying heat power on the DC – contact

This test is passed, if one of the following requirements is fulfilled:

- The d.c. electric vehicle supply equipment performs an error shutdown sequence according to **A-4.3.5** for System A and **B-3.4** for System C within 9 s after the reference temperature sensor signals a temperature of more than 90°C ; or
- The d.c. electric vehicle supply equipment reduces the output current (less than 2 A) before the temperature measured by the reference temperature sensor reaches 90°C .

The test shall be performed two consecutive times.

101.4.3.4 Test for self-diagnostics function for thermal management system

For System A, the test is performed with a RD according to Fig. 18 and a test arrangement according to Fig. 19.

For System C, the test is performed with a RD according to Fig. 22 and a test arrangement according to Fig. 23.

The DUT shall be stored for at least 2 h at $55 \pm 4^\circ\text{C}$

The test shall be executed at rated current and may be executed at the minimum output voltage of the DUT.

The test shall be executed for the following test sequences:

- Once thermal stabilization has been reached, the thermal transport device, for example cooling pump, shall be switched off; and
- Once thermal stabilization has been reached, the thermal exchange device, for example cooling unit, shall be switched off.

After switching off the corresponding device, the DUT shall be operated for an additional 60 min.

This test is passed if:

- the measured temperatures by the reference temperature sensors do not exceed 90°C and;
- the temperature limits according to 16.5 of IS 17017 (Part 2/Sec 1) : 2020 are not exceeded at any touchable and graspable surface of the DUT (for system C only) or the temperature limits according to **A-9.1** are not exceeded (for system A only).

NOTE — Pass criteria can be achieved by reducing the available output current.

101.4.3.5 Test for availability of thermal sensing devices — General

For System A, the test is performed with a RD according to Fig. 18 and a test arrangement according to Fig. 19.

For System C, the test is performed with a RD according to Fig. 22 and a test arrangement according to Fig. 23.

The DUT shall be equipped with a disconnecting device in each signalling path of thermal sensing.

Tests shall be conducted for each of the following test setups:

- a) signalling path of thermal sensing on DC+ contact open and signalling path of thermal sensing on DC– contact closed; and
- b) signalling path of thermal sensing on DC+ contact closed and signalling path of thermal sensing on DC– contact open

101.4.3.6 Test for availability of thermal sensing devices before charging

The availability of each thermal sensing device shall be checked before each charging session.

After setting the disconnecting devices in the positions according to **101.4.3.5**, a charging session shall be initiated.

This test is passed if:

- a) the DUT starts a supply process with the current assigned by the manufacturer of the cable assembly for operation without thermal exchange and/or thermal transport or the DUT does not start a supply process until serviced (for System A only)
- b) the DUT does not start a supply process until serviced (for System C only).

101.4.3.7 Test for availability of thermal sensing devices during charging

The DUT shall be operated at rated current and may be operated at the minimum output voltage.

Then the disconnecting devices shall be set in the positions according to **101.4.3.5**.

This test is passed if:

- a) the DUT reduces output current to the current assigned by the manufacturer of the cable assembly for operation without thermal exchange and/or thermal transport or trigger an error shutdown according to **A-4.3.5** within 9 s after the occurrence of the fault (for System A only)
- b) trigger an error shutdown according to **B-3.4** within 9 s after the occurrence of the fault (for System C only)

101.5 Specific Requirements for Temperature Controlled Charging

The d.c. electric vehicle supply equipment may allow a boost current exceeding the rated current of the cable assembly based on agreement between cable assembly manufacturer and d.c. electric vehicle supply equipment manufacturer as long as the temperature requirement of the d.c. contact assembly according to **101.4.1.1** is fulfilled for the condition required by the

d.c. electric vehicle supply equipment manufacturer. The boost current shall not exceed the maximum rated current for each system according to Table 108 in IEC TS 62196-3-1 : 2020.

Temperature controlled charging shall be mutually agreed between manufacturers of the d.c. electric vehicle supply equipment and the cable assembly.

Compliance is checked by inspection and test in **101.4.3.2**.

This clause is applicable for System A and System C.

102 TEST REQUIREMENTS

102.1 Technical Data

The following information from the manufacturer shall be provided for compliance test:

- a) operating points (**102.2.4**);
- b) operating temperature range;
- c) operating humidity range; and
- d) a.c. supply voltage.

In addition to above, the information on additional operating points with a maximum output ripple, if any, shall be provided for System C.

102.2 General Test Conditions

102.2.1 Ambient Test Conditions

102.2.1.1 Environmental conditions

Unless otherwise specified, all tests shall be carried out under the following test conditions:

- a) temperature: $(25 \pm 10) ^\circ\text{C}$;
- b) atmospheric pressure: 86 kPa to 106 kPa (86 kPa); and
- c) relative humidity: 10 percent to 90 percent (without condensation).

102.2.1.2 Test power requirements

Power to the tested device shall be according to IS 12360, if designed to be supplied by utility supply network.

- a) a.c. power frequency: 50 ± 0.5 Hz;
- b) a.c. power voltage: $240/415 \text{ V} \pm 10$ percent;
- c) d.c. component on a.c. power: the offset less than 2 percent of the peak value;
- d) degree of voltage unbalance on a.c. power: less than 5 percent; and
- e) a.c. power waveform: sinusoidal, with a distortion factor less than 8 percent.

102.2.2 Measuring Instruments

The characteristics of the measuring equipment shall be suitable to verify the specified values in the corresponding test items.

The equipment for measurement of voltage, current, temperature and time shall be according to IS/ISO/IEC 17025 and IEC Guide 115.

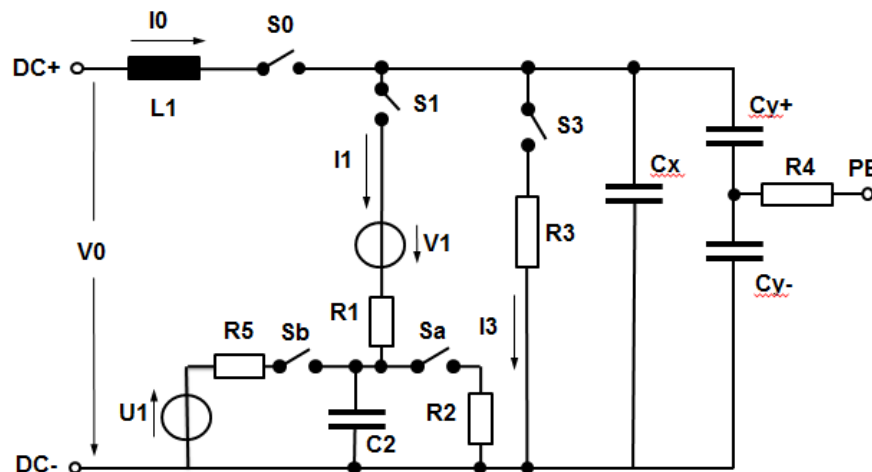
102.2.3 Test Load

An artificial load such as a resistive load, an electronic load and a voltage source (for example battery) shall be used. An electronic load operating under constant resistance mode is not considered as a resistive load. The artificial load requires an additional vehicle control

simulator to establish analogue interface and/or digital communication with the d.c. electric vehicle supply equipment.

Unless otherwise specified, a resistive load or an electronic load shall be used for the compliance tests. An example of the test load, represented by a simplified equivalent circuit diagram, is shown in Fig. 126.

Recommended circuit parameters of the test load for each system are shown in Table 16.



Key

Cx	X-capacitor (positive-negative)	I1	emulated current to traction battery
Cy+	Y-capacitor (positive-earth)	I3	emulated current to auxiliary load
Cy−	Y-capacitor (negative-earth)	L1	inductor
C2	capacitor for emulating traction battery	R3	resistor for emulating auxiliary load
I0	output current of d.c. electric vehicle supply equipment	R5	current-limiting resistor for U1
U1	electronic load/controlled voltage source	PE	protective conductor
V1	ideal voltage source	S0, S1,	contactor (switch)
V0	output voltage of d.c. electric vehicle supply equipment	S3, Sa, Sb	
R1, R2	variable resistor to set operating voltage point		
R4	resistor for emulating the voltage surge between positive-negative, positive-earth and negative-earth		

FIG. 26 EXAMPLE OF ARTIFICIAL LOAD

NOTE — The simplified equivalent circuit diagram of the charging circuitry in Figure 26 is used for specifying the test conditions relevant to the test cases contained in this document, e. g. present voltage and internal resistance of the electric vehicle battery. Only those electric properties of the electric vehicle charging circuitry are modelled that are relevant for checking conformity of an d.c. electric vehicle supply equipment with the requirements in this document. Properties of the charging circuitry of a real electric vehicle which are not relevant for checking conformity are not modelled by this diagram. It is important to note that this diagram does not mandate how a real test bench implements the electrical properties of the electric vehicle charging circuitry that are relevant for a specific test case. It is rather recommended to use a battery simulator to implement these properties, but it needs to be ensured that the test conditions given in the test case specifications are obeyed.

Table 16 Recommended Circuit Parameters of the Test Load
(Clause 102.2.3)

Symbol	System A	System C
L1	0 H	0 H
Cx	Not used	470 μ F
Cy+/-	4.7 nF	2 μ F
C2	5600 μ F	5600 μ F
S0	As specified in respective test	As specified in respective test
S1	As specified in respective test	As specified in respective test
S3	Open	As specified in respective test
Sa	Open	Closed
Sb	Closed	Open
R1	Variable (10-2 000 m Ω)	Variable (50-100 m Ω)
R2	Variable (Set by the required voltage operating point)	Variable (0.1-2 m Ω)

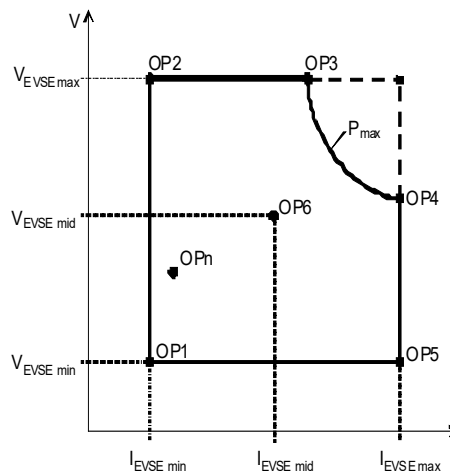
Symbol	System A	System C
R3	Not used	10 Ω (up to 500 V) 50 Ω (500-1 000 V)
R4	50 Ω	50 Ω
R5	Variable	Not used
U1	0-1 000 V	Not used
V1	Not used	0-1 000 V

102.2.4 Testing Point

102.2.4.1 Definition

Fig. 27 shows the range of operating voltage and current which can be output by the d.c. electric vehicle supply equipment, and some specific operating points OP1, OP2, OP3, OP4, OP5 and OP6 used as testing points in **101.2.1**.

If the d.c. electric vehicle supply equipment shows any discontinuous behaviour in its operating range, for example in case of cascaded architecture of power modules, it might be necessary to add additional testing points OPn.



Key

$I_{EVSE\ max}$	maximum operating current of d.c. electric vehicle supply equipment	OP1	$V_{EVSE\ min}$ and $I_{EVSE\ min}$
$I_{EVSE\ mid}$	$(I_{EVSE\ max} + I_{EVSE\ min})/2$	OP2	$V_{EVSE\ max}$ and $I_{EVSE\ min}$
$I_{EVSE\ min}$	minimum operating current of d.c. electric vehicle supply equipment	OP3	$V_{EVSE\ max}$ and P_{max}
$V_{EVSE\ max}$	maximum operating voltage of d.c. electric vehicle supply equipment	OP4	$I_{EVSE\ max}$ and P_{max}
$V_{EVSE\ mid}$	$(V_{EVSE\ max} + V_{EVSE\ min})/2$	OP5	$V_{EVSE\ min}$ and $I_{EVSE\ max}$
$V_{EVSE\ min}$	minimum operating voltage of d.c. electric vehicle supply equipment	OP6	$V_{EVSE\ mid}$ and $I_{EVSE\ mid}$
OP	operating point		
OPn	voltage and current depending on test conditions		

FIG. 27 OPERATING POINTS

ANNEX A

(Clause 1, 6.3.113.3, 7.1 ,7.1.101 and 16.2.1.2)

D.C. EV SUPPLY EQUIPMENT OF SYSTEM A

A-1 GENERAL

This annex provides the specific requirements for the d.c. electric vehicle supply equipments of System A (hereinafter also referred to as “System A station” or “station”), in addition to the general requirements as defined.

System A is a regulated d.c. charging system using a dedicated CAN communication circuit for digital communication between a d.c. electric vehicle supply equipment and an electric vehicle for control of d.c. charging. The vehicle coupler of Configuration AA as specified in IS 17017 (Part 2/Sec 3) : 2020 is applicable to System A. The specific requirements for digital communication and details of the communication actions and parameters of System A are defined in Annex A of IS 17017 (Part 24).

Rated output voltage of system A station does not exceed 1000 V d.c..

This system is suitable for the passenger vehicles and light trucks.

This annex defines the system with an a.c. input, but does not prohibit d.c. input. This annex includes information on the circuits on vehicle side.

This annex is also applicable to the d.c. electric vehicle charging/discharging station of System A. Unless otherwise provided for, the requirements for System A station in this standard is also applicable to the charging/discharging station. For general information regarding bi-directional power flow, refer to Annex C.

More detailed information on System A is defined in IEEE 2030.1.1.

A-2 SCHEMATIC AND INTERFACE CIRCUIT DIAGRAM

The schematic block diagram of System A is given in Fig. 28. The interface circuit between the station and the vehicle for charging control is shown in Fig. 29. CAN-bus circuit is provided for digital communication with the vehicle. The definition and description of symbols and terms in Fig. 28 and Fig. 29 are given in Table 17. The values of the parameters for the interface circuit are given in Table 18.

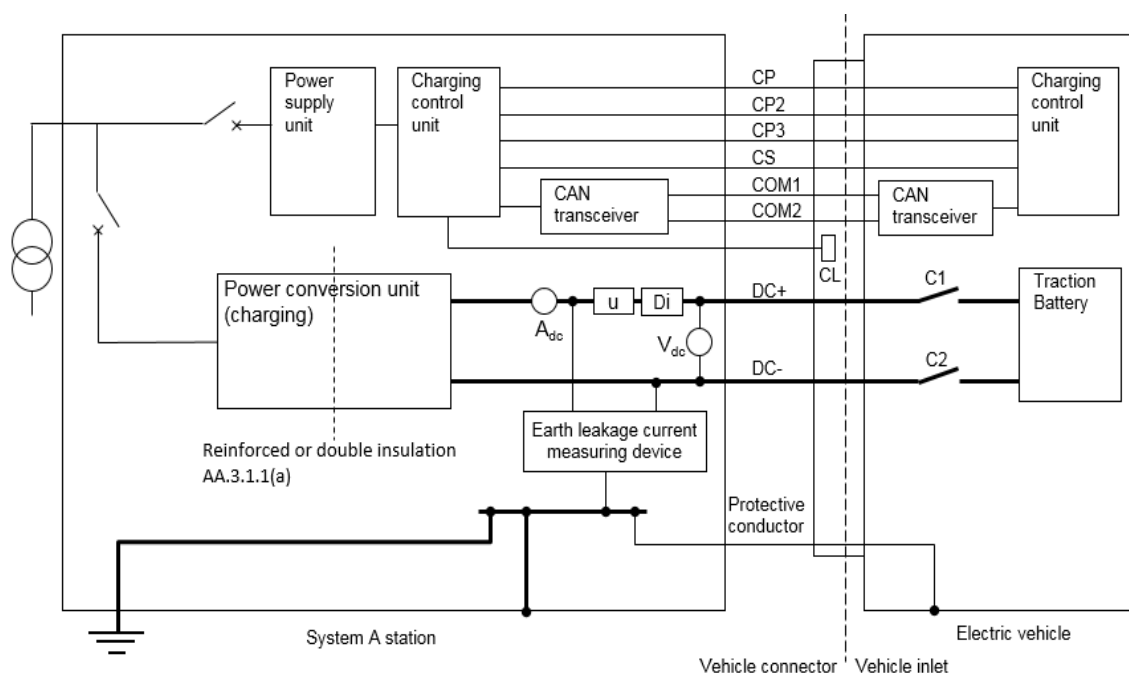


FIG. 28 OVERALL SCHEMATIC OF SYSTEM A STATION AND EV

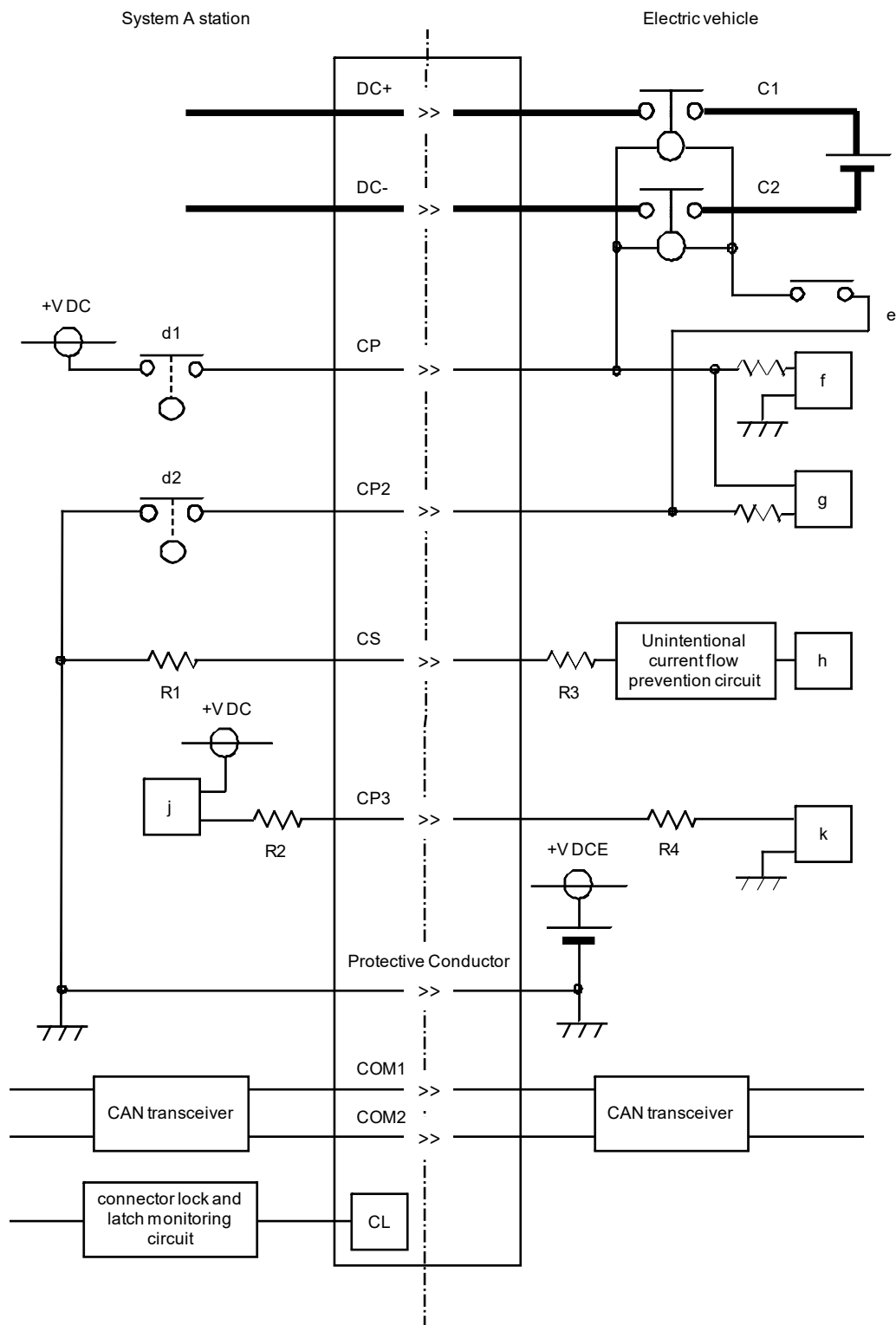


FIG. 29 INTERFACE CIRCUIT FOR CHARGING CONTROL OF SYSTEM A STATION

Table 17 Definition of Symbols of Overall Schematics of System A Station
(Clause A-2)

	Symbols	Definitions	Requirements
System A station	Di	Reverse-current-prevention device (for example diode: cathode on the vehicle side, anode on the station side)	101.1
	d1	Switch on CP for controlling the charging start/stop signals from the station to the vehicle	Table 18, A-3.7, A-4
	d2	Switch on CP for controlling the charging start/stop signals from the station to the vehicle	Table 18, A-3.7, A-4
	j	Signal sensing device to detect vehicle ready/not ready to accept energy	A-4
	Vdc	Voltage measurement device	A-3.3, A-4.4
	Adc	Current measurement device	A-4.4
	u	Short-circuit protection device (for example current limiting fuse) In case the vehicle connector has the short-circuit protection device, station A may not have the one.	A-3.5
	R1	Resistor	Table 18
	R2	Resistor	Table 18
	V DC	d.c. power supply to electric vehicle contactors	Table 18, A-3.12
Electric vehicle	C1,C2	Disconnection switch for d.c. power lines (electric vehicle contactors)	A-3.7, A-3.8, A-3.15, A-4
	e	Relay for turning on electric vehicle contactors	A-4
	f	Signal sensing device to detect the status of d1	A-4
	g	Signal sensing device to detect the status of d2	A-4
	h	Signal sensing device to detect connection/disconnection of vehicle coupler	A-4
	k	Switch to give the go ahead/stop to charge	A-4
	R3	Resistor	Table 18
	R4	Resistor	Table 18
	+V DCE	d.c. power supply in the vehicle	Table 18
	DC+	d.c. power supply (positive)	A-3.15
Terminal and wire	DC–	d.c. power supply (negative)	A-3.15
	CP	Control pilot which indicates the start/stop status of station	Table 18
	CP2	Control pilot which indicates the start/stop status of station	Table 18,
	CS	Pilot wire which indicates the status of vehicle coupler connection	Table 18, A-3.14
	CP3	Control pilot which confirms that the vehicle is ready for charging	Table 18, A-3.2, A-3.8.2
	COM1 COM2	Signal line pair for digital communication	A-3.2, A-4, Annex A of IS 17017(Part 24).
	protective conductor	Protective conductor between the station and electric vehicle for detecting the first d.c. earth fault	A-3.1.1, A-3.8.2
	AS1	Auxiliary power supply from the vehicle (in-connector terminal)	Table 18, A-6.2.10
	AS2	Auxiliary power supply from the vehicle (external terminal)	Table 18, A-6.2.10
Vehicle connector	CL	Connector latching and latching mechanism	A-3.3, A-3.6

Table 18 Parameters and Values for Interface Circuit of System A Station
(Clause A-2)

System A Station					
Terminal/Wire	Parameters	Minimum value	Typical value	Maximum value	Unit
CP	+V DC	10.8	12.0	13.2	V
CS	Resistor R1	190	200	210	W
CP3	Resistor R2	950	1 000	1 050	W
CP	Load current of switch d1	2		2 000	mA
CP2	Load current of switch d2	2		2 000	mA
AS1	Voltage		12	16	V
	Current			6.4	A
AS2	Voltage		12	16	V
	Current			6.4	A
Electric Vehicle					
CP	Load current (when d1 and d2 closing)	10		2 000	mA
CP2	Load current (when d1 and d2 closing)	10		2 000	mA
CS	Resistor R3	950	1 000	1 050	W
	+ V DCE	8	12	16	V
CP3	Resistor R4	190	200	210	W
AS1	Voltage		12	16	V
	Current			6.4	A
	Rated fuse			10	A
	Voltage		12	16	V

NOTE — Voltage of AS1 or AS2 is different from + V d.c.

For bi-directional power flow application, resistance of AS1, AS2 and protective conductor: Each resistance shall be less than the line resistance equivalent to the one on the conditions of conductor temperature 80 °C, 1.25 mm² and 7.5 m (15 m for round-trip).

A-3 SPECIFIC SAFETY REQUIREMENTS

A-3.1 Fault Protection in the Secondary Circuit

A-3.1.1 General

For fault protection in the secondary circuit, System A station shall have the following measures:

- reinforced or double insulation between the a.c. supply circuit and the d.c. output circuit according to 4.4.7 of IEC 62477-1 : 2016. If the a.c. supply circuit and the d.c. output circuit are insulated at the commercial frequency input port of power converter, an isolating transformer according to IEC 61558-2-4 may be used;

NOTE — (a) includes the isolating transformer and all associated circuits of the secondary circuit.

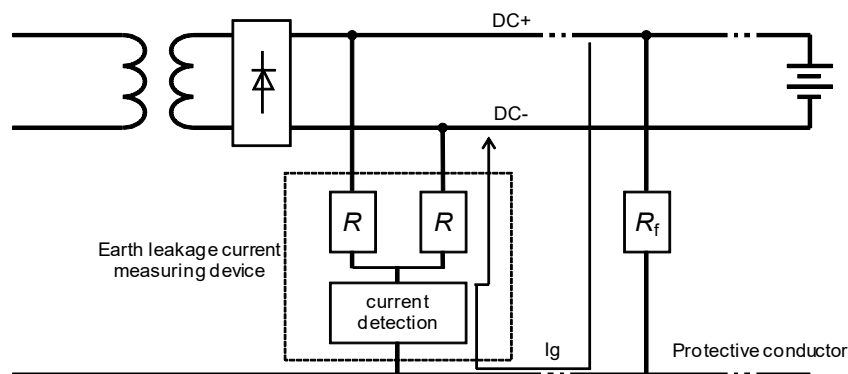
- earth leakage current measurement using a grounding resistor between the d.c. power lines DC+/- and earth (enclosure and chassis);
- automatic disconnection of supply to d.c. power circuit at the first d.c. earth fault;
- charging cable consisting of line conductors that are individually insulated.

When protective conductor forms part of a charging cable, the cross-sectional area of protective conductor shall be determined by the formula in 543.1.2 of IEC 60364-5-54 : 2011. The minimum cross-sectional area of the protective conductor of charging cable shall be 0.75 mm².

Table 19 shows the principle of fault protection. System A station shall comply with case 1.

Table 19 Principle of Fault Protection
(Clause A-3)

	Power supply to electric vehicle in case of the first fault	Protection measure in case of the first fault	Protection against the secondary fault
Case 1	Not allowed	Automatic shutdown	Prohibition of operation at the first fault
Case 2	Allowed	– Detection and notice of the first fault using an insulation monitoring device – Recommendation for elimination of the first fault with the shortest practicable delay	– PE equivalent to TN ground required – Visible warning for system operator at the detection of symmetric fault



Key

R_f : insulation resistance between DC+/DC– and vehicle or enclosure at the first fault

R : grounding resistor to detect and limit the first fault current

I_g : earth leakage current at the first earth fault

FIG. 30 FAILURE DETECTION PRINCIPLE BY DETECTION OF D.C. LEAKAGE CURRENT

The requirements in **A-3.1** also apply to the bi-directional power flow system.

A-3.1.2 Automatic Disconnection and Earth Fault Monitoring

System A station shall measure the earth leakage current between the secondary circuit and its enclosure, or between the secondary circuit and the vehicle chassis.

The station shall detect the first earth fault before and during charging within 1 s, and then shall perform an error shutdown.

The procedure of earth fault detection before charging is provided in **A-4.3.3**.

Specific requirements on the timing criteria for the error shutdowns are given in Table 21.

Fault current detection principle and performance requirements are defined in Fig. 30 and Table 20.

A-3.2 De-Energization of the Power Supply to the EV

The compliance to **6.3.1.5** shall be checked according to the following tests.

- a) TEST 1; and
 - 1) Connect the d.c. electric vehicle supply equipment to an artificial load;
 - 2) Start charging with the procedure specified by charger manufacturer;
 - 3) Stop digital message transmission from electric vehicle simulator; and
 - 4) Check the d.c. electric vehicle supply equipment initiates error shutdown after 1 s elapsed from (3).

Table 20 Requirements for Earth Fault Monitoring
(Clause A-3.1.2)

Item	Detection performance
Maximum detection time a	Less than 1 s
Nuisance trip prevention	Minimum response time shall be more than 0.2 s with continuous threshold monitoring
Sensitivity b	Sensitivity of earth leakage current measuring device and grounding resistor of 'R' shall be designed so that the body current of human at the first earth fault is within DC-2 zone in Fig. 22 of IEC 60479-1 : 2005.
a The detection time does not include shutdown time of d.c. output current. b The actual body current may differ from the measured leakage current I_g, which should be taken into account when designing the station. Example Set-up condition 1: When the body current I_h exceeds DC-2 zone calculated by Formula (5), a measurement device is designed to detect the deterioration of insulation resistance R_f as the first earth fault by measuring earth leakage current shown in Formula (6). $I_h = V_{dc} \times (R + R_f) / (R \times R_f) \quad (5)$ where I_h is the body current V_{dc} is the line to line voltage of d.c. output circuit R is a grounding resistor R_f is an insulation resistance $I_g = V_{dc} / (R + 2 \times R_f) \quad (6)$ where I_g is the measuring current Set-up condition 2: The measurement device is designed to detect the body current within DC-2 zone, except the set-up condition 1.	

b) TEST 2.

- 1) Connect the d.c. electric vehicle supply equipment to an artificial load;
- 2) Start charging with the procedure specified by charger manufacturer;
- 3) Turn off CP3 signal between the station and electric vehicle; and
- 4) Check the d.c. electric vehicle supply equipment triggered emergency shutdown after (3).

NOTE — The compliance can also be checked according to the test specified by the manufacturer.

A-3.3 Voltage Measurement of d.c. Power Line for Vehicle Connector Unlatch

According to 6.3.1.103, the vehicle connector shall not be unlatched when hazardous voltage is detected. To unlatch the vehicle connector, the voltage of d.c. power line shall be measured at V_{dc} in Fig. 28, and be confirmed to be within safe levels, that is 10 V or less.

Compliance is checked by the following test:

- a) Connect the d.c. electric vehicle supply equipment to a test load with a dedicated electric vehicle simulator. The setup of the test load in Fig. 26 is in Table 16;

- b) Start charging with the procedure specified by charger manufacturer;
- c) Confirm that the vehicle connector is latched on a vehicle inlet before insulation check;
- d) After insulation check, close switch S0;
- e) Stop charging with the procedure specified by charger manufacturer;
- f) Open switch Sa; and
- g) Confirm that the vehicle connector remains latched on a vehicle inlet while the voltage at the inlet terminals is higher than 10 V.

A-3.4 Overcurrent Protection of the d.c. Connection

The d.c. electric vehicle supply equipment shall provide an overcurrent protection to protect the power supply circuit of the d.c. electric vehicle supply equipment and the vehicle. If the following condition is continuously fulfilled for a duration of 5 s, the d.c. electric vehicle supply equipment shall trigger an error shutdown.

- a) at current ≥ 50 A: current is exceeding 120 percent of the request value from the electric vehicle; and
- b) at current < 50 A: current is exceeding the request value from the electric vehicle by 10 A or more.

Compliance is demonstrated by design review.

A-3.5 Short-Circuit Protection of d.c. Connection

Short circuit protection means, such as current-limiting fuse u , shall be provided in the output circuit of System A station in order to protect the circuits of the station and the vehicle from short circuit.

The short-circuit protection device shall meet the following requirements:

- a) quick-break type; and
- b) normal melting rating: not higher than 400 000 A²s.

The cross sectional area of main conductors of charging cable shall have a short-circuit current withstanding rating (I^2t) at least 6 400 000 A²s.

When the vehicle connector is equipped with short circuit protection means, the short circuit withstand rate of the charging cable may be reduced.

NOTES

1 Vehicle battery short circuit, by reverse connection of the cable etc, causes huge short circuit current.

2 The system A electric vehicle provides short circuit protection device which protects the charging cable assembly with I^2t of 2 500 000 A²s (see ISO 17409).

Compliance is checked by inspection.

A circuit block diagram indicating that the control circuit power supply is separated from the a.c. supply network and from the power line shall be provided by the manufacturer.

A-3.6 Latch Monitoring for Vehicle Connector

A-3.6.1 General

The vehicle connector shall have a means of mechanical latching, electrical latching, and latch monitoring.

It shall also have a means to provide System A station with information on anomaly detection in monitoring of latch and electrical latching. Fig. 31 shows an example of a detection means in vehicle connector and System A station.

A-3.6.2 Latch Monitoring for Vehicle Connector not Equipped with Short Circuit Protection

Vehicle connector not equipped with short circuit protection means shall constantly monitor the state of the latch holding circuit during charging operation.

In case of failure of mechanical latching or electrical latching of the vehicle connector, the station shall not

energize the d.c. power lines connected to the vehicle connector. If a failure is detected during charging, the station shall reduce the d.c. output current to less than 5 A within 2 s. Then, the switch $d1$ shall be opened.

A-3.6.3 Latch Monitoring for Vehicle Connector Equipped with Short Circuit Protection

The vehicle connector equipped with short circuit protection means shall have a latching device with self-holding mechanism. When hazardous voltage is present at the contact terminals of vehicle connector, the vehicle connector shall be kept latched to the vehicle inlet if the latch holding circuit of the vehicle connector fails.

The vehicle connector which has the self-holding mechanism does not need to constantly monitor the state of, or detect an error in, the latch holding circuit during charging operation.

A-3.7 Protection of EV Contactor

In order to prevent the welding of electric vehicle contactor, switches $d1$ and $d2$ shall not open at current exceeding 5 A.

A-3.8 Fault Conditions and Criteria for Transfer to Error and Emergency Shutdown

A-3.8.1 Error Shutdown

System A station shall perform an error shutdown according to 6.3.1.116.

Table 21 provides the shutdown times and criteria of error shutdown.

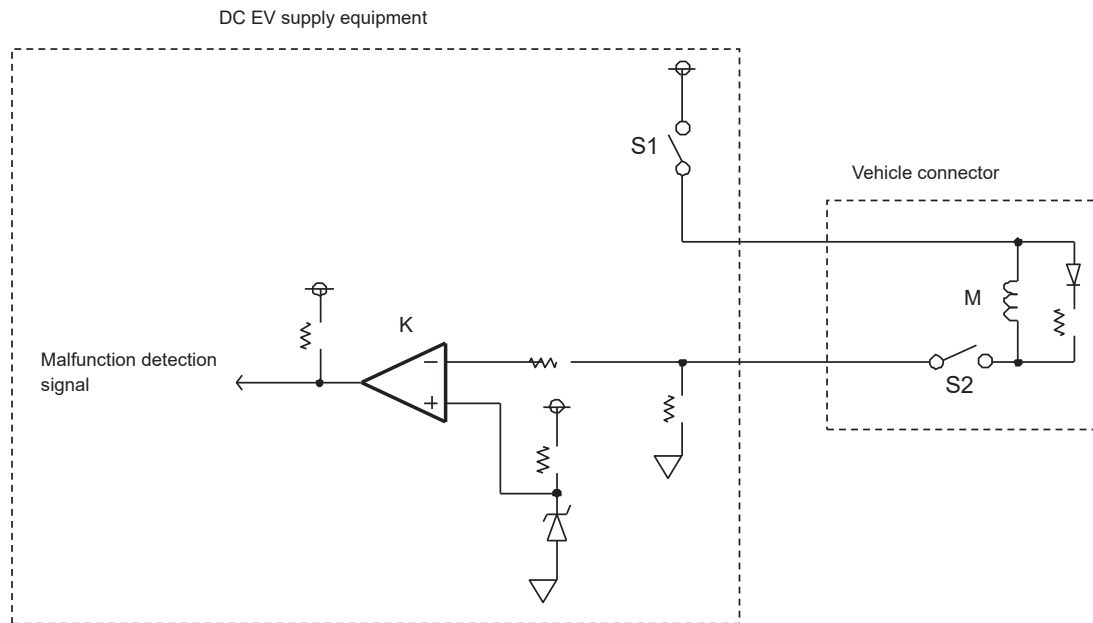
After detection of errors, System A station shall send the messages to the vehicle by digital communication [refer to Table A.3 of IS 17017 (Part 24)].

Table 22 and Table 23 provide the message parameter exchanges and relevant actions of error shutdown.

A-3.8.2 Emergency Shutdown after Control Pilot Disconnection

The System A station shall decrease the output current to 5 A or less within 30 ms after the loss of the continuity (disconnection) of the control pilot CP3.

Table 24 and Table 25 provide the emergency shutdown times, actions and criteria.



Key

K: comparator

S1: switch

S2: switch, interlocked with latching

M: solenoid

FIG. 31 EXAMPLE OF VEHICLE CONNECTOR LATCH MONITORING CIRCUIT

Table 21 Error Shutdown Times and Criteria
(Clause A-3.8.1)

Fault	Response time of station to start shutdown	Output current descending rate	Shutdown triggered by	General	Output voltage descending rate	Condition to unlatch vehicle connector
Loss of CAN communication ^a (6.3.1.5, A-3.2)	1 s	$\Delta I_{out} > 200$ A/s	Station	The station shall reduce its output to: Output current $\leq 5A$ ^c Output voltage $\leq 60V$ between DC + and DC- and $\leq 28 V$ between DC+ and earthing terminal, and DC- and earthing terminal ^d (see Fig. 32)	(see A-3.15)	After shutdown process is completed and output voltage $\leq 10V$ (see Fig. 32).
Overvoltage at the interface (6.3.1.106)	2 s					
Overvoltage between DC+/- and PE in case of single first earth fault (6.3.1.113)	5 s					
Over temperature of d.c. contact assemblies (101.4.2.2, 101.4.3.3, A-9.2)	9 s					
Thermal sensing fault (101.4.2.3)	9 s					
Insulation fault between DC + or DC- and protective conductor (A-3.2)	1 s					
Over current of d.c. power line (A-3.4)	5 s					
Malfunction of latch device (latch position) (A-3.6.1, A-3.6.2)	0.1 s					
Malfunction of latch device (latch holding circuit) (A-3.6.1, A-3.6.2)	0.1 s					
Error shutdown specified by the manufacturer including earth fault on the AC primary circuit, and short circuit on the a.c. primary circuit	Specified by manufacturer					
Under-voltage at the interface ^b (A-6.2.12)	2 s	Specified by manufacturer see A-3.3	Vehicle			
Short circuit of d.c. power line (13.3)	3 s					
Vehicle requested error shutdown by sending: H'102.4.X = 1, or H'102.5.2 = 1, or switch k = OFF	1 s: CAN 0.1 s: switch K	$\Delta I_{out} > 200$ A/s	Vehicle			
^a Loss of CAN communication means 1 s continuous disruption and no data frame of CAN communication. ^b Mandatory for bi-directional systems ^c electric vehicle should disconnect the power circuit between station and electric vehicle by opening electric vehicle contactor when the output current of station is decreased less than or equal to 5A. ^d Voltage at the vehicle connector terminals. The station can reduce the voltage after the electric vehicle contactor is opened.						

Table 22 Action and Message Parameter for error Shutdown Triggered by the Station
(Clause A-3.8.1)

Step	Action	Message parameter	Criterion
1	Fault detected		
2	Start error shutdown process and notification to the vehicle	H'109.5.1 = 1 or H'109.5.4 = 1 & H'109.5.5 = 1	Send message parameters to the vehicle
3	Charging current control		$< 3 \text{ s}$ and $\Delta I_{\text{out}} > -200 \text{ A/s}$
4	Notification to the vehicle and move to step 6, when the station cannot allow welding detection by the vehicle.	H'108.0.0 = 0 & H'109.5.0 = 1	Send message parameter to the vehicle when the current reached 5 A or less
5	Notification to the vehicle and move to step 6 of Table 23, when the station can allow welding detection by the vehicle.	H'108.0.0 = 1 & H'109.5.0 = 1	Send message parameter to the electric vehicle when the current has reached 5 A or less
6	D1, D2 = OPEN		$\leq 1 \text{ s}$ from step 4
7	Voltage removal		$\leq 2 \text{ s}$ and $V_{\text{dc}} < 10 \text{ V}$ from the end of the step 5
8	Unlatched or remain latched		Specified by the manufacturer

Table 23 Action and Message Parameter for error Shutdown Triggered by the Vehicle
(Clause A-3.8.1)

STEP	Vehicle			Station		
	Action	Message parameter	Criterion	Action	Message parameter	Criterion
1	Fault detected					
2	Request for error shutdown	H'102.4.X = 1 or H'102.5.2 = 1 or switch (k) = OFF				
3				Start error shutdown process	H'109.5.5 = 1	Send message parameters to the vehicle
4				Charging current control		$\leq 3 \text{ s}$ and $\Delta I_{\text{out}} \geq -200 \text{ A/s}$
5				Notification to the vehicle	H'108.0.0 = 1 H'109.5.0 = 1	Send message parameters to the vehicle when the current reached 5 A or less
6	Welding detection	H'102.5.3 = 1	welding detection time $\leq 4 \text{ s}$ send the message to the station after finishing welding detection			
7				D1, D2 = OPEN		$\leq 1 \text{ s}$ from step 6
8				Voltage removal		$\leq 2 \text{ s}$ and $V_{\text{dc}} \leq 10 \text{ V}$ from the end of the step 7
9				Unlatched or remain latched		Specified by manufacturer

Table 24 Emergency Shutdown Times and Criteria
(Clause A-3.8.2)

Fault	Trigger of emergency shutdown	Response time of station to start emergency shutdown process	Maximum time to near zero current (5 A) from fault occurrence	Maximum time to reach safe voltage from fault occurrence
Loss of electrical continuity of protective conductor (6.3.1.2) Disconnection of vehicle coupler during charge (9.101, A-4.3.5.3)	Loss of continuity of the control pilot CP3	Immediately after the fault	< 30 ms	< 1 s < 60 V between DC + and DC – and ≤ 28 V between DC+/- and earthing terminal

Table 25 Actions and Criteria for Emergency Shutdown
(Clause A-3.8.2)

Step	Action	Criterion
1	Fault detected CP3 loss	
2	Charging current shutoff	≤ 5 A & ≤ 30ms from step 1
3	$V_{dc} < 60$ V between DC+ and DC – and ≤ 28 V between DC+/- and earthing terminal	≤ 1 s from step 1

A-3.9 Turn on Inrush Current for Vehicle Circuit

When electric vehicle contactor is closed, inrush current on d.c. power line of System A station shall not exceed 20 A at vehicle connector.

A-3.10 Output Current Regulation in CCC

The variation of the output current of the d.c. electric vehicle supply equipment from the required value (target current) sent by the electric vehicle in steady state operation shall be less than or equal to ± 2.5 A for the requirement below 50 A, and less than or equal to ± 5 percent of the required value of 50 A or more.

System A specific test conditions for compliance test in 101.2.2.1 are as shown below.

The setup of the test load is shown in Table 26 and Fig. 26.

Table 26 System A Setup of the Test Load for Output Current Regulation in CCC

(Clause A-3.10)

Switches					Circuit parameter setup
S0	S1	S3	Sa	Sb	
close	close	open	open	close	L1: 0 H R1, R5: 0 Ω (bypassed) V1: Not used U1: An electronic load operating under constant voltage mode shall be used.

For 4) in 101.2.2.1, record I_{EV} target and I_{EVSE} output at the following operating points: OP1, OP2, OP3, OP4, OP5 and OP6.

Recommended steps for sweeping the output voltage and current of the d.c. electric vehicle supply equipment are shown in Table 27.

Table 27 System A Recommended Steps for Output Current Regulation in CCC

(Clause A-3.10)

Step	Action	Description
1	Set $U1 = V_{EVSE \min}$.	Transmit; Target battery current = 0 (A)
2	Set $I_{EV \text{ target}} = I_{EVSE \min}$ to check OP1.	Transmit; Target battery current = 5(A)
3	Set $I_{EV \text{ target}} = I_{EVSE \max}$ to check OP5.	Transmit; Target battery current = $I_{EVSE \max}$ (A)
4	Increase U1 up to V_{EVSE} output = $P_{EVSE \max} / I_{EVSE \max}$ to check OP4.	–
5	Set U1 to $V_{EVSE \max}$ to check OP3	Before setting U1 to $V_{EVSE \max}$, transmit; Target battery current = $P_{EVSE \max} / V_{EVSE \max} - 5$ (A)
6	Set $U1 = V_{EVSE \min}$ to check OP2.	–

A-3.11 Periodic and Random Deviation (Current Ripple)

The compliance to **101.2.5** shall be checked according to the following tests:

- Connect the artificial load with electric vehicle simulator to the station. Select the value of R2 in accordance with $I_{EVSE\ max}$ and the voltage at which the OP4 in Fig. 27 shall be operated. For example if $I_{EVSE\ max} = 200\ A$ and the voltage at OP4 = 400 V, $R2 = 400\ V/200\ A = 2\ \Omega$;
- Connect a current probe to the measuring instrument (oscilloscope of 20 MHz) and clamp the current probe to the d.c. power line in the output of the station;
- Start charging according to the procedure specified by the station manufacturer, with $I_{EV\ target1} = I_{EVSE\ min}$, where $I_{EV\ target1}$ is the initial current command value from electric vehicle simulator for OP1 in Fig. 27.
- Wait for T_{dmax1} until the steady state operation is reached.

$$T_{dmax1} > 1 + \frac{I_{EV\ target1}}{20}$$

where T_{dmax1} is the time for the output current of station to reach $I_{EV\ target1}$ and the steady state, expressed in seconds (s).

- Set the current command value = $I_{EV\ target2}$ in electric vehicle simulator to operate the station at OP4.
- Wait for T_{dmax2} until the steady state operation is reached.

$$T_{dmax2} > 1 + \frac{I_{EV\ target2} - I_{EV\ target1}}{20}$$

where T_{dmax2} is the time for the output current of station to reach $I_{EV\ target2}$ and the steady state, expressed in seconds (s).

- Measure the maximum peak-to-peak value of the output current after the first order low pass filtering (LPF).
- Check that the maximum peak-to-peak value is within the limit for each cut-off frequency in Table 13.

The measuring instrument and conditions shall comply with the requirements specified in Table 28.

Table 28 Specification of Measuring Instrument
(Clause A-3.11)

Item	Performance
Oscilloscope	Bandwidth: 0-20 MHz or more Sampling rate: 1 MS/s or more Record length: 1 M point or more Record span: 1.1 s or more Vertical resolution: 12 bits or more
Current probe	Rated current: Maximum output current of the station or more Bandwidth: 0-300 kHz or more Measurement accuracy: within ± 1 percent

A-3.12 Load Dump

In any case of load dump, voltage overshoot of d.c. output of the station shall not exceed the voltage limit specified in Table 29.

Table 29 Voltage Limit for Load Dump
(Clause A-3.12)

Target battery voltage ^a of vehicle (U)	Voltage limit in case of load dump V
$U \leq 500\ V$	600
$500\ V < U \leq 750\ V$	900
$750\ V < U \leq 1\ 000\ V$	1 200

^a Table A.2 of IS 17017(Part 24).

A-3.13 Power Supply to Vehicle for Actuation of EV Contactors

System A station shall provide a power supply to the vehicle via terminal d1 for the actuation of electric vehicle contactors C1 and C2, with a rated voltage of 12 V and the maximum rated output power of more than 24 W.

Instead of using the 12 V power supply from the station, the vehicle may provide the power source for the actuation of the electric vehicle contactors. In such case,

- The vehicle should be capable of reducing the voltage of the d.c. power line terminals of the vehicle inlet to less than 60 V between DC+ and DC– and less than 28 V between DC+ and earthing terminal, and DC– and earthing terminal

within 1 s after the disconnection of the charging connector from the vehicle inlet.

NOTES — By using the 12 V power supply from the station as a power source for the actuation of the electric vehicle contactors, the unexpected closure of the electric vehicle contactors when the charging connector is not mated to the vehicle inlet can be prevented.

- b) The vehicle should not close the electric vehicle contactors when the vehicle connector is not mated to the vehicle inlet.

NOTES — The vehicle can continuously monitor the status of charging connector proximity by checking the condition of one or more of the signals CP, CP2, COM1 and COM2.

A-3.14 Pilot Wire for Monitoring Vehicle Coupler Connection

The pilot wire (CS) shall be electrically or mechanically disconnected from the vehicle control circuit during the period from a) to b):

- a) the closure of switch k (after Handshaking)
- b) the opening of the electric vehicle contactor C1 and C2 (after Energy transfer).

NOTES

1 The requirement is achieved by the unintentional current-flow prevention circuit on the vehicle. See Fig. 29 and Fig. 38.

2 Vehicle may connect CS to the vehicle control circuit before the closure of the switch k and after the opening of the electric vehicle contactor C1 and C2, (DC-B'3 and DC-B'4). By monitoring CS, the vehicle can prevent the unexpected drive when the vehicle connector is mated to the vehicle inlet, before and after the charging.

A-3.15 Impedance of Output Circuit

In the time period between T3 and T4 in Fig. 33, the line impedance between DC+ and DC– from the reverse current prevention device Di in the output circuit of System A station to the vehicle connector shall be as follows:

- a) capacitance: 1 μ F or less; and
- b) resistance: 40 k Ω or more.

A-3.16 Assistance of Welding Detection

The station shall fulfil the following conditions when, from the vehicle inlet to the open electric vehicle contactor, the capacitance between DC+ and DC– is less than or equal to 1 μ F:

- a) Within 1 s after opening the electric vehicle contactor, the voltage at vehicle connector shall be less than 25 percent of the d.c. output voltage at the end of the charging;
- b) Within 2 s after opening the electric vehicle contactor, the voltage at vehicle connector shall be less than 10 V.

A-4 CHARGING PROCESS AND COMMUNICATION BETWEEN D.C. EV SUPPLY EQUIPMENT AND ELECTRIC VEHICLE FOR CHARGING CONTROL

A-4.1 Charging State

Table 30 defines the charging state of d.c. electric vehicle supply equipment. The charging states show physical status of d.c. electric vehicle charging system. The d.c. electric vehicle supply equipment and the vehicle can exchange their charging state through the signal communication and the digital communication.

Charging control process as system action level is shown in Table 31.

A-4.2 Communication Measures

Communication between the station and the vehicle is carried out through the control pilots CP, CP2 and CP3, proximity circuit CS, and the digital communication circuits COM1 and COM2. CP and CP2 transmit signals such as “ready to charge” and “end of charge” from the station to the vehicle. CP3 is used to transmit instructions to start charging or shutdown, from the vehicle to the station. Numerical parameters in Annex A of IS 17017 (Part 24) such as output rating of station and maximum voltage of battery are exchanged through COM1 and COM2.

A-4.3 Charging Control Process

A-4.3.1 State Transition Diagram and Sequence Diagram

The charging process of System A shall conform to the state transition diagram as shown in Fig. 32. Fig. 33 gives the charging control sequence under normal conditions.

A-4.3.2 Start of Charging

When the charging process is initiated by System A station, d1 shall be closed. The switch d2 shall be open until the end of insulation check in A-4.3.3.

A-4.3.3 Insulation Check before Charging

The insulation check shall not start until the vehicle provides System A station with a permission signal through CP3, and permission parameters by digital communication as shown in Annex A of IS 17017 (Part 24). Before the insulation check, System A station shall inform the vehicle through digital communication that vehicle connector is latched.

The insulation check shall be performed in accordance with 6.3.1.105 and as the following procedure:

Table 30 Charging State of d.c. EV Supply Equipment
(Clause A-4.1)

State		Vehicle connected	Vehicle contactor	Charging possible	Description
DC-A	Not connected	No	Open	No	Vehicle unconnected
DC-B1	Initialization	Yes	Open	No	Vehicle connected/not ready to accept energy/communication not established/connector unlatched or latched/vehicle contactor open
DC-B2		Yes	Open	No	Vehicle connected/not ready to accept energy/communication established/connector unlatched or latched/vehicle contactor open
DC-B3		Yes	Open	No	Vehicle connected/not ready to accept energy/communication established/connector latched/vehicle contactor open/other supplemental processes not completed
DC-C	Energy transfer	Yes	Close	Yes	Vehicle connected/ready to accept energy/indoor charging area ventilation not required/communication established/connector latched/vehicle contactor close/other supplemental processes completed
DC-D		Yes	Close	Yes	Vehicle connected/ready to accept energy/indoor charging area ventilation required/communication established/connector latched/vehicle contactor close/other supplemental processes completed
DC-B'1	Shutdown	Yes	Close	Yes	Vehicle connected/charging finished/communication maintained/connector latched/vehicle contactor close
DC-B'2		Yes	Open	No	Vehicle connected/charging finished/communication maintained /connector latched/vehicle contactor open/other supplemental processes completed
DC-B'3		Yes	Open	No	Vehicle connected/charging finished communication maintained/connector unlatched/vehicle contactor open
DC-B'3-1		Yes	Open	No	Vehicle connected/charging finished/communication maintained/connector latched/vehicle contactor open
DC-B'4		Yes	Open	No	Vehicle connected/charging finished/communication finished/connector unlatched/vehicle contactor open
DC-B'4-1		Yes	Open	No	Vehicle connected/charging finished/communication finished/connector latched/vehicle contactor open
DC-B'4-2		Yes	Open	No	Vehicle connected/charging finished/communication finished/connector unlatched/vehicle contactor open
DC-E	Error	Yes	Open	No	d.c. electric vehicle supply equipment disconnected from vehicle/d.c. electric vehicle supply equipment disconnected from utility, d.c. electric vehicle supply equipment loss of utility power or control pilot short to control pilot reference.
DC-F	Malfunction	Yes	Open	No	Other d.c. electric vehicle supply equipment problem

Table 31 Charging Control Process of d.c. EV Supply Equipment at System Action Level
(Clause A-4.1)

Charging control stage (process)		State	High level action a
Initialization	Handshaking	DC-A	Vehicle unconnected
		DC-B1	Connector plugged in
		DC-B1	Wake up of DCCCF and VCCF
		DC-B1	Communication data initialization
		DC-B1→DC-B2	Communication established, parameters exchanged, and compatibility checked
	Charge preparation	DC-B2→DC-B3	Connector latched
		DC-B3	Insulation check for d.c. power line
Energy transfer		DC-C or DC-D	Vehicle side contactors closed
		DC-C or DC-D	Charging by current demand (CCC)
		DC-C or DC-D	Charging by voltage demand (CVC) (<i>under consideration</i>)
		DC-C or DC-D→ DC-B'1	Current suppression
		DC-C or DC-D	Renegotiate parameter limits (option)
Shutdown (case 1)		DC-B'1	Zero current confirmed
		DC-B'1→DC-B'2	Welding detection (by vehicle, option)
		DC-B'2	Vehicle side contactors open
		DC-B'2	d.c. power line voltage verification
		DC-B'3	Connector unlatched
		DC-B'4	End of charge at communication level
		DC-A	Connector unplugged
Shutdown (case 2) ^b		DC-B'1	Zero current confirmed
		DC-B'1→DC-B'2	Welding detection (by vehicle, option)
		DC-B'2	Vehicle side contactors open
		DC-B'2	d.c. power line voltage verification
		DC-B'3-1	Connector remain latched
		DC-B'4-1	End of charge at communication level
		DC-B'4-2	Connector unlatched or remain latched
		DC-A or DC-B1	Connector unplugged or remain plugged in
^a The order of actions does not refer to the procedure of charging control process.			
^b In some use cases, such as billing service, the vehicle connector can continue to be latched after the charge is finished.			

FIG. 32 STATE TRANSITION DIAGRAM OF CHARGING PROCESS

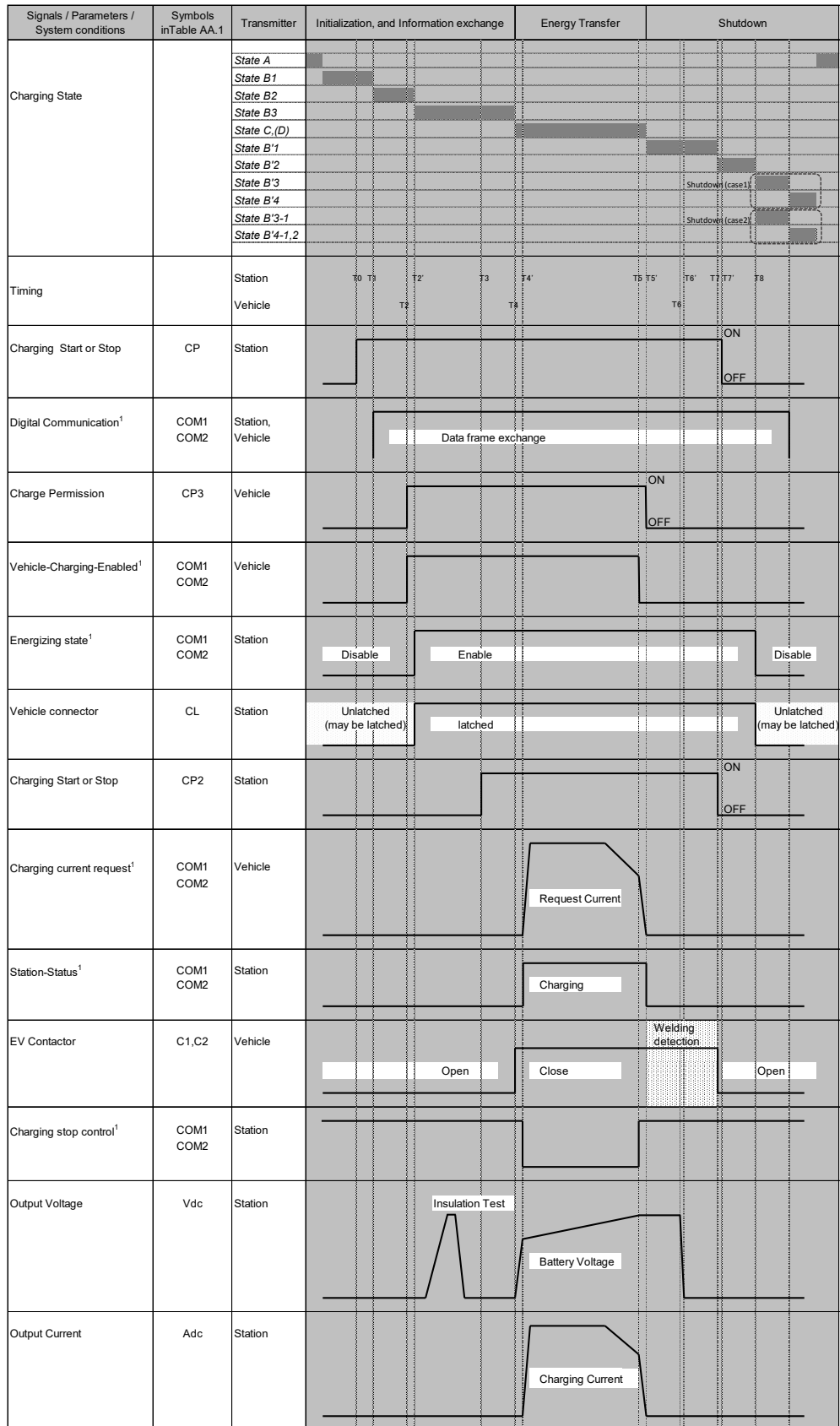
¹ See IEC61851-24 Annex A

FIG. 33 SEQUENCE DIAGRAM OF CHARGING

- a) Before the insulation check, the station shall measure V_{dc} of d.c. power line and confirm that electric vehicle contactors are open. The voltage of d.c. power line, measured at V_{dc} , shall be less than 10 V. If the measured voltage is more than or equal to 10 V, the charging process shall be shut down (*see* Fig. 32).
- b) The voltage U that is applied to the d.c. power line shall be Target battery voltage (H'102.1, H'102.2) or Available output voltage (H'108.1, H'108.2), whichever is lower. Voltage accuracy shall be within ± 5 percent. If the voltage is less than 500 V, it shall be set to 500 V ± 5 percent. After the insulation check, it shall be confirmed that the voltage at V_{dc} is less than or equal to 20 V. Then, the station shall inform the vehicle of the termination of insulation check with closing d2 switch. During the insulation check, the earth fault shall be monitored in accordance with A-3.1.2. When earth fault is detected, error shutdown shall be performed.

The compliance of the insulation check function shall be confirmed with the following test.

a) Test Setup

Connect test load (Fig. 26) and fault resistance R_t to the station (DUT) according to Fig. 5. Switch S0 in the Test load shall remain open during the test.

b) Test Scenarios

The DUT shall be checked under all test scenarios specified in Table 32.

Table 32 Test Scenarios
(Clause A-4.3.3)

Test Scenarios	Fault Resistance (R_t)	Location of R_t
Scenario 1	Not used	-
Scenario 2	$U^1 \times 100$	Between DC+ and PE ³
Scenario 3	Sufficiently low resistance ²	Between DC+ and PE ³
Scenario 4	$U^1 \times 100$	Between DC- and PE ³
Scenario 5	Sufficiently low resistance ²	Between DC- and PE ³

¹ According to A-4.3.3 b)

² Select sufficiently low resistance to represent 0 Ω insulation fault. Examiner can select the appropriate value for the resistance.

³ In this Table, PE means "protective conductor".

c) Result

The DUT shall satisfy the following requirements

- 1) Insulation check voltage shall comply with the requirement in item (b) of A-4.3.3 in test scenario 1. DUT shall keep the insulation check voltage U for more than 0.2 s after the voltage reached U .
- 2) In the scenarios 2, 3, 4, and 5, the DUT shall judge the insulation failure within 1 s after the insulation check voltage reached U .
- 3) For scenario 1, DUT shall transition to the next charging state.
- 4) For scenarios 2, 3, 4, and 5, DUT shall perform the following process.
 - i) DUT shall notify electric vehicle (electric vehicle simulator) the insulation failure by CAN communication. The DUT shall use data bit "H'109.5.1" specified in Annex A of IS 17017(Part 24). DUT shall stop applying insulation check voltage within 1 s.
 - ii) DUT shall transit to shutdown state.

NOTE — Some DUT needs a certain time period to reach the insulation check voltage U .

A-4.3.4 Energy Transfer

System A shall continuously monitor the charging current value requested by the vehicle. The charging current shall be changed responding to the vehicle requested value, in accordance with CCC requirements in 101.2.2.1 and 101.2.3. The characteristics of charging current control shall meet A-5.

A-4.3.5 shutdown

A-4.3.5.1 Normal shutdown

System A station shall comply with the following procedure for normal shutdown:

- a) The station shall notify the vehicle of start of shutdown process by digital communication.
- b) The station shall reduce the output current to 5 A or less with the current descending speed specified in Table 36.
- c) Switches d1 and d2 shall not be open until the welding detection of electric vehicle contactor by vehicle is finished.
- d) After d1 and d2 open, it shall be confirmed that the voltage at V_{dc} is 10 V or less. The station shall keep connector latched, if the voltage at V_{dc} is more than 10 V.

Table 33 and Table 34 define the normal shutdown time, actions and criteria.

Table 33 Normal Shutdown Times and Criteria

(Clause A-4.3.5.1)

Trigger	Response time of station to start normal shutdown process	Maximum time to near zero current (5 A) from the start of normal shutdown process	Maximum time to reach connector unlatched
Vehicle	≤ 0.5 s from trigger	≤ 3 s and $\Delta I_{out} \geq -100$ A/s	≤ 7.5 s
Station	According to the specification given by the manufacturer		

Table 34 Actions and Message Parameters for Normal Shutdown

(Clause A-4.3.5.1)

STEP	Vehicle			Station		
	Action	Message parameter	Criterion	Action	Message parameter	Criterion
1	Request of normal shutdown	H'102.5.0 = 0 or H'102.5.1 = 1 & H'102.3 = 0	Send the parameters to the station			
2 ^a				Notify the vehicle of start of normal shutdown	H'109.5.5 = 0	Send the parameter to the vehicle
3				Charging current control		≤ 3 s and $\Delta I_{out} \geq -100$ A/s
4				Notification to the vehicle	H'109.5.0 = 1	Send the message to the vehicle when the current reached 5 A or less
5	Welding detection	H'102.5.3 = 1	Welding detection time ≤ 4 s Send the message to the station after finishing welding detection			
6				d1, d2 = OPEN		≤ 1.5 s from the end of step 5
7				Voltage removal		≤ 2 s and $V_{dc} \leq 10$ V from the end of the step 6
8				Unlatched or remain latched		Specified by the manufacturer

^a When the station triggers normal shutdown, the shutdown process starts from step 2.**A-4.3.5.2 Error shutdown**

System A station shall comply with the following procedure for error shutdown:

- The station shall notify the vehicle of start of shutdown process by digital communication.
- The station shall reduce the output current to 5 A or less with the current descending speed specified in Table 36.
- If the shutdown is triggered by electric vehicle, switches d1 and d2 shall not be open until the welding detection of electric vehicle contactor by vehicle is finished.
- If the shutdown is triggered by System A station, switches d1 and d2 shall be opened within 0.5 s or less after b).

- After d1 and d2 open, it shall be confirmed that the voltage at V_{dc} is 10 V or less. The station shall keep connector latched, if the voltage at V_{dc} is more than 10 V.

A-4.3.5.3 Emergency shutdown

System A station shall start emergency shutdown as follows, when detecting the loss of CP3 signal:

- The station shall reduce the output current to 5 A or less within 30 ms;
- If the station uses CP3 signal as emergency shutdown detection, switches d1 and d2 shall not be open until the welding detection of electric vehicle contactor by vehicle is finished;
- If the station uses CP or CP2 signal as emergency shutdown detection, switches d1 and d2 shall be opened within 0.5 s or less after b); and

- d) After d1 and d2 open, it shall be confirmed that the voltage at V_{dc} is 10 V or less. The station shall keep connector latched, if the voltage at V_{dc} is more than 10 V.

A-4.4 Measuring Current and Voltage

The voltage and current shall be continuously monitored and reported within 0.5 s including measurement delay and digital communication (CAN) transmission delay.

The accuracy of output measurement reported via digital communication of system A shall be within the following values:

- a) Current: $\pm$ (1.5 percent of actual output current + 1) A
- b) Voltage: $\pm$ 5 V

Refer to Fig. 34 for a more precise definition of the accuracy of output measurement with respect to the target current and the actual output current defined in 101.2.2.1.

A-5 RESPONSE TO VEHICLE COMMAND ON CHARGE CURRENT

System A station shall supply d.c. current to the vehicle using CCC with the vehicle as the master and d.c. electric vehicle supply equipment as the slave. Recommended specification for the charge current request from the vehicle and the response performance of System A station are given in Table 35 and Fig. 35 for the vehicle, and in Table 36 and Fig. 36 for system A station.

NOTE — Table 35 and Fig. 35 also apply to the maximum available current in bi-directional flow system operating under charging/discharging seamless-switchover mode.

A-6 BI-DIRECTIONAL POWER FLOW (OPTIONAL)

A-6.1 Schematic and Interface Circuit Diagram

The schematic block diagrams of the charging/discharging station of System A are given in Fig.37 and Fig. 38.

The interface circuit between the station and the vehicle for charging/discharging control is shown in Fig. 39. The definition and description of symbols and terms in figures are given in Table 17. The values of the parameters for the interface circuit are given in Table 18.

A-6.2 Functional Requirements

A-6.2.1 General

In addition to the functional requirements specified in 6.3.1.1, the d.c. electric vehicle charging/discharging station shall draw a current from the vehicle in electric vehicle discharging mode, of which the maximum value is limited by the maximum available current of the vehicle battery in electric vehicle discharging mode.

The following functions shall be provided by the d.c. electric vehicle charging/discharging station:

- a) verification that the vehicle is compatible with the discharging process (A-6.2.2);
- b) information that the station is compatible with the discharging process (A-6.2.2, A-6.2.3); and
- c) specific requirements for the latching of the coupler (A-3.6).

A-6.2.2 Compatibility Check with Bi-Directional Power Flow

The charging and discharging processes shall be managed by both the vehicle and the d.c. electric vehicle charging/discharging station. The bi-directional power flow control shall only be activated when both the vehicle and the d.c. electric vehicle charging/discharging station are compatible with the electric vehicle discharging process. The compatibility shall be checked by both sides during the initialization stage of the establishment of digital communication. Both the station and the vehicle shall also implement a means to disable the bi-directional power flow control in case the user does not wish the vehicle to be discharged.

A-6.2.3 Control States for EV Charging/Discharging Mode

In electric vehicle charging/discharging mode, the d.c. electric vehicle charging/discharging station should either:

- a) control the current drawn from the vehicle within the limit of the maximum available current of the vehicle battery specified by the vehicle; or
- b) control the current supplied to the vehicle within the limit of the VCCF request.

The transition between the two states should be performed seamlessly or sequentially, and may be requested by vehicle, user, d.c. electric vehicle charging/discharging station or utility.

A-6.2.4 Seamless State Transition

In electric vehicle charging/discharging seamless-switchover mode, the d.c. electric vehicle charging/discharging station should transit between charging and discharging without changing the energy transfer state defined in Table 37.

A-6.2.5 Sequential State Transition

The d.c. electric vehicle charging/discharging station should first transfer to the shutdown states as defined in Table 30 and Table 37 before transiting from one mode to the other.

NOTE — 101.2.2.1 and 101.2.3 are not applicable to the bi-directional power flow system operating in electric vehicle charging/discharging seamless-switchover mode.

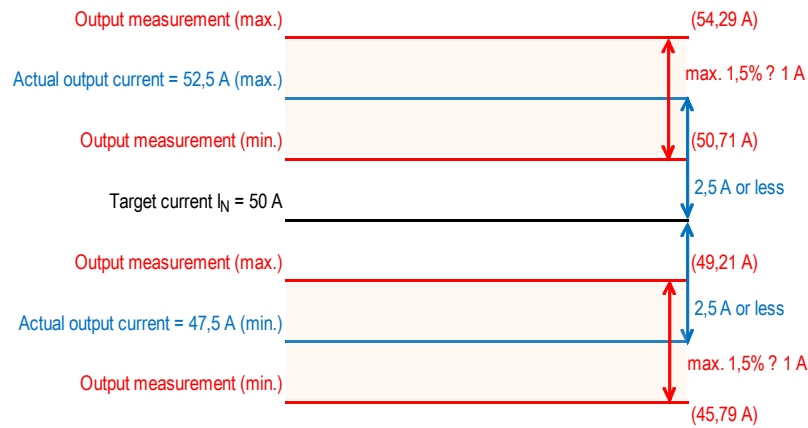


FIG. 34 ACCEPTABLE RANGE OF OUTPUT MEASUREMENT (TARGET CURRENT I_N : 50A)

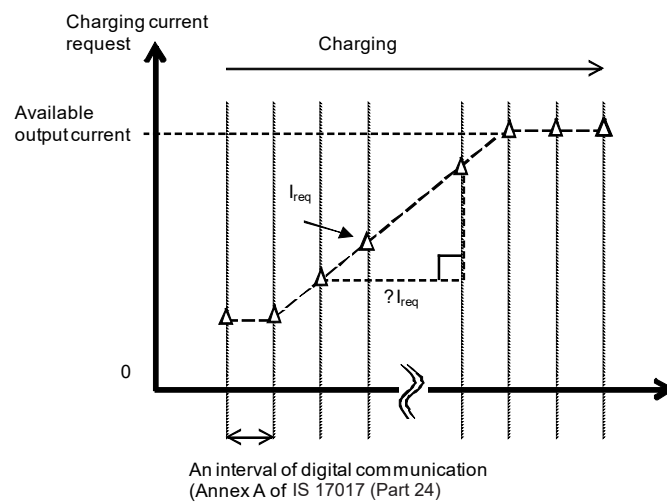
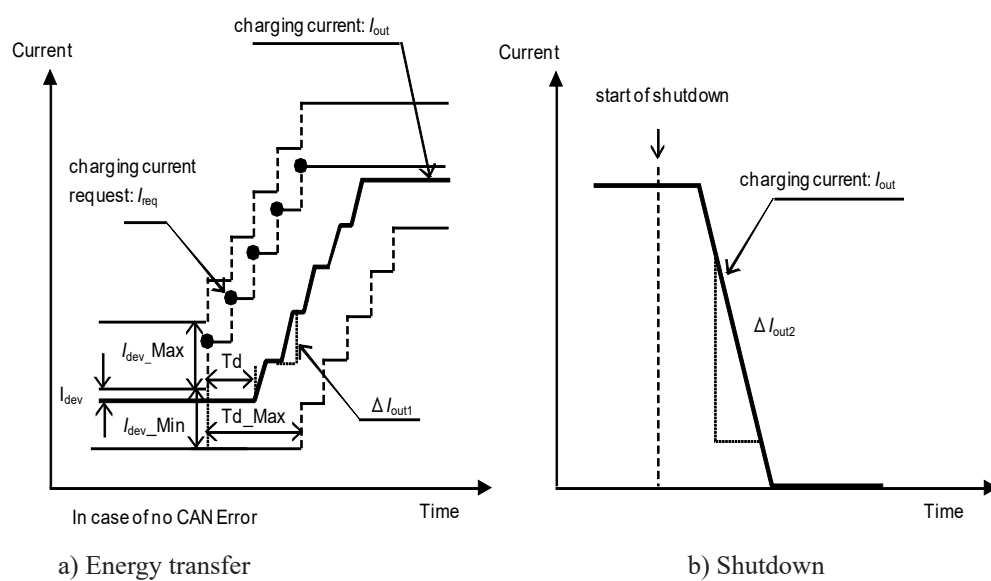


FIG. 35 CHARGING CURRENT VALUE REQUESTED BY THE VEHICLE



a) Energy transfer

b) Shutdown

FIG. 36 OUTPUT RESPONSE PERFORMANCE OF D.C. EV SUPPLY EQUIPMENT

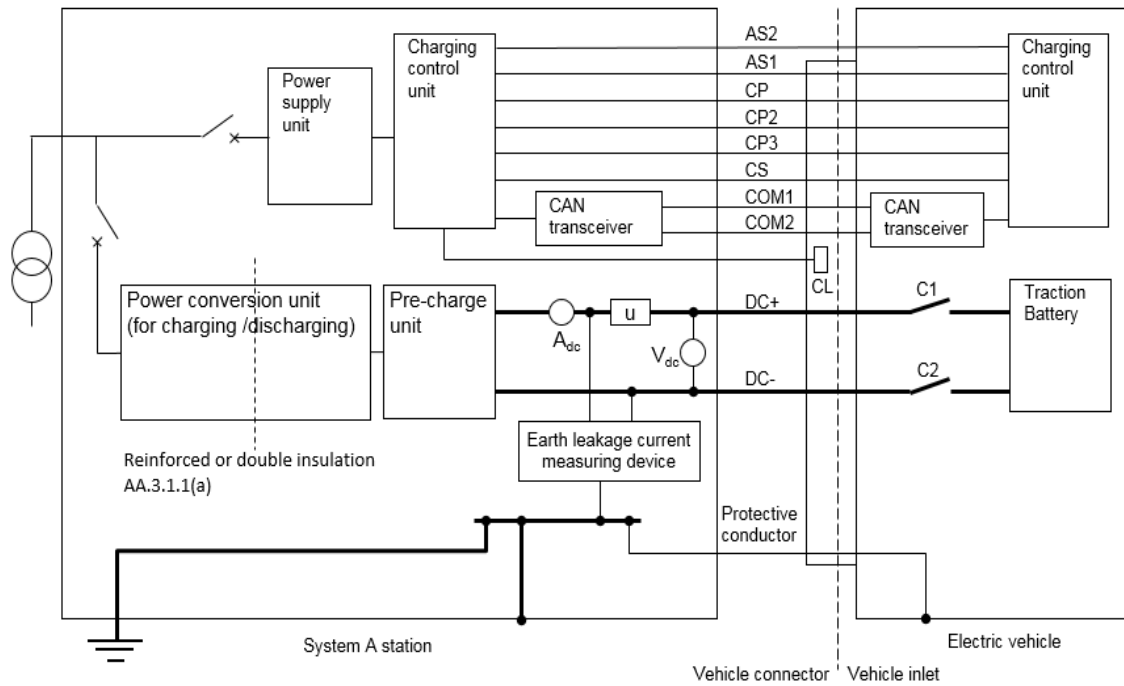


FIG. 37 OVERALL SCHEMATIC OF SYSTEM A CHARGING/DISCHARGING STATION AND EV
(CHARGING/DISCHARGING INTEGRATION TYPE)

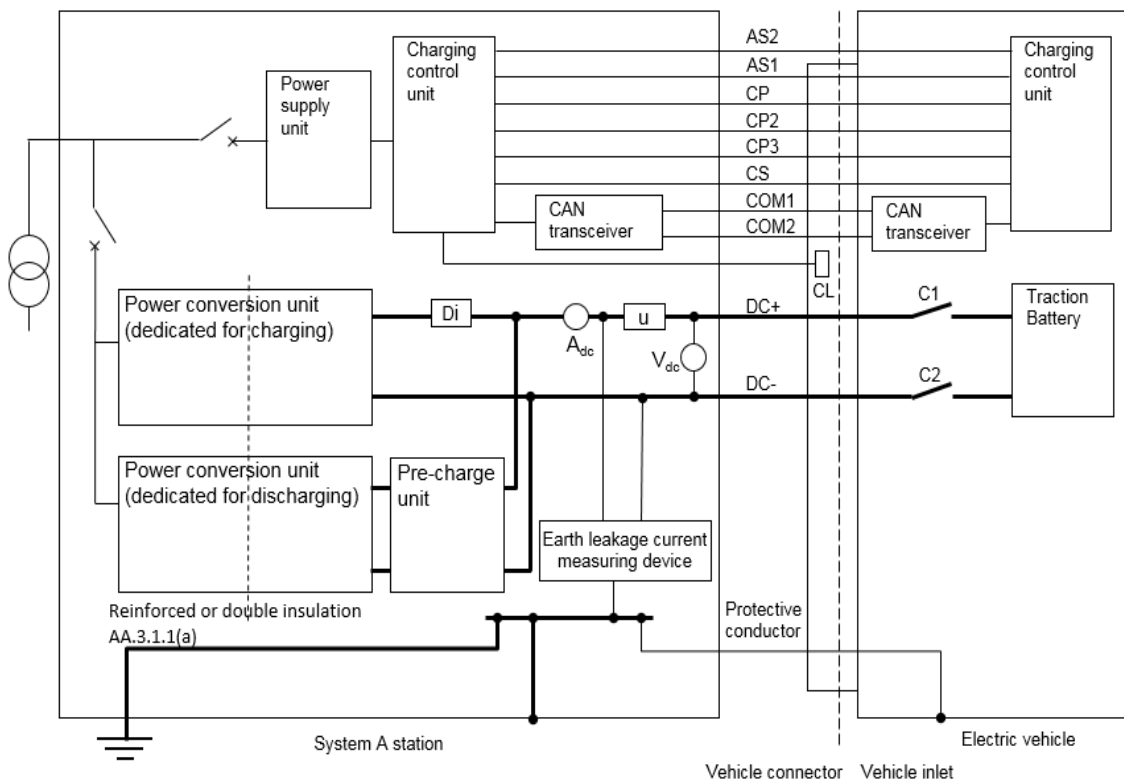
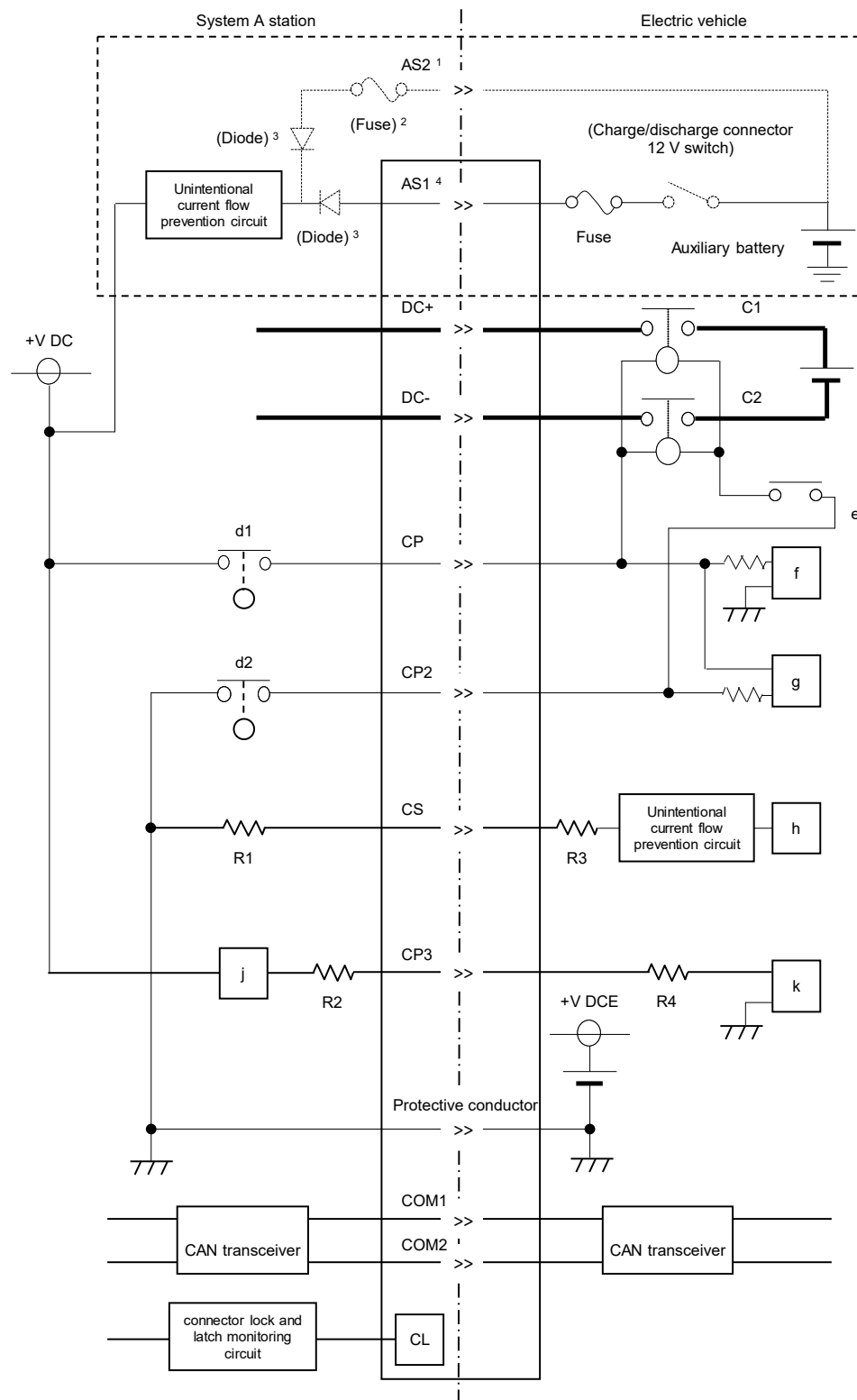


FIG. 38 OVERALL SCHEMATIC OF SYSTEM A CHARGING/DISCHARGING STATION AND EV
(CHARGING/DISCHARGING SEPARATION TYPE)



NOTES

- 1 AS2 (optional) to which the power is supplied from cigarette socket.
- 2 The fuse is a reference example, for example a fuse in a cigarette socket.
- 3 The diode is a reference example. It prevents reverse current to the auxiliary battery.
- 4 AS1 is optional.

FIG. 39 INTERFACE CIRCUIT FOR CHARGING/DISCHARGING CONTROL OF SYSTEM A STATION

Table 35 Recommended Specification of Charging Current Requested by the Vehicle
(Clause A-5)

Item	Symbol	Condition	Specification		
			Minimum	Maximum	Unit
Charging current request range	I_{req}		0	Available output current (IS 17017 (Part 24)-Annex A)	A
Rate of demand value change	DI_{req1}		–20	20	A/s

Table 36 Requirements for the Output Response Performance of d.c. EV Supply Equipment
(Clause A.5)

Item	Symbol	Condition		Specification		
				Minimum	Maximum	unit
Output accuracy	I_{dev}	Charging current request	0 to 5 A	0 ($I_{dev} - \text{Min}$)	$I + 2.5 \text{ A}$ ($I_{dev} - \text{Max}$)	A
			5 to 50 A	$I - 2.5 \text{ A}$ ($I_{dev} - \text{Min}$)	$I + 2.5 \text{ A}$ ($I_{dev} - \text{Max}$)	
			50 A to 400 A	$I \times 95 \text{ percent}$ ($I_{dev} - \text{Min}$)	$I \times 105 \text{ percent}$ ($I_{dev} - \text{Max}$)	
Control delay to vehicle request	T_d			–	1.0 ($T_d - \text{Max}$)	s
Output response speed	DI_{out1}	At charging		20	–	A/s
Output current descending speed ^b	DI_{out2}	normal shutdown		100	200	
		error shutdown		200	–	
		emergency shutdown		200 a	–	
^a In case of disconnection of CP, CP2 or CP3 during charging, faster termination of charging current is required. <i>See A-3.8.2.</i>						
^b The requirement for the output current descending speed also applies to the bi-directional power flow system. All the other values in this table are not applicable to the bi-directional power flow system.						

A-6.2.6 Specific Requirements for Connection with a Vehicle which does not Support EV Discharging

Unless otherwise specified, the d.c. electric vehicle charging/discharging station shall be capable of charging a vehicle which does not support electric vehicle discharging.

A d.c. electric vehicle charging/discharging station which does not meet this requirement should display a written label that clearly indicates the incapability.

NOTE — This subClause is not applicable to the station or equipment specifically designed for electric vehicle discharging for example a portable Vehicle-to-Load (V2L) power supply.

A-6.2.7 Description of Process of Shutdown

Normal shutdown should occur when the vehicle battery state of charge reaches a certain limit, or when the charging/discharging process is stopped by the user with a normal stop means.

Error shutdown or emergency shutdown should occur under a fault condition (*see 6.3.1.114*). After completion of charging/discharging session, the shutdown phase allows the vehicle and the d.c. electric vehicle

charging/discharging station to return to the conditions so that the user can safely handle the charging cable and the vehicle connector.

When the end of charging/discharging is notified by the vehicle, the d.c. electric vehicle charging/discharging station should reduce the charge/discharge current to zero. The vehicle side contactors open at near zero current. The d.c. electric vehicle charging/discharging station may unlatch the vehicle connector if the voltage at the inlet between DC+ and DC– reaches less than 60 V, and less than $\leq 28 \text{ V}$ between DC+ and earthing terminal, and DC– and earthing terminal (*see 6.3.1.107*).

A-6.2.8 Pre-Charge when EV Contactor is Closed

The pre-charge circuit shall be designed so that the inrush current shall not exceed 20 A when electric vehicle contactors are closed (*see A-3.9*).

A-6.2.9 Power Supply for Control Circuit of Charging/Discharging Station

The auxiliary power supply for the control circuit of d.c. electric vehicle charging/discharging station shall

be isolated from the power line DC+ and DC– by basic insulation, except the connection circuit for earth-fault detection.

Double or reinforced insulation is required in case that a single fault as defined in IEC 61140 causes an electric shock hazard.

Except those that are specifically designed for discharging and are not intended to be connected to an a.c. supply network, for example a portable Vehicle-to-Load (V2L) power supply, the station shall have means to supply auxiliary power to its control circuit in case of an unexpected loss of a.c. input power such as blackout, and shall remain operational under such condition as defined in **A-6.2.10**.

In order to avoid any nuisance to the vehicle, the internal d.c. to d.c. converter for auxiliary power supply, if any, shall be activated at least 1 s after the closure of the electric vehicle contactors.

A-6.2.10 Auxiliary Power Supply from the Vehicle (Optional)

The vehicle may provide an optional function in which the auxiliary power to the station is supplied through the optional pin of the charging connector, or the cigarette lighter socket. In such cases, charging/discharging control of the station may be started (and operated) by the auxiliary power supplied from the vehicle, and the station shall draw the auxiliary power through the terminals AS1 or AS2 shown in Fig. 37 and Fig. 38.

Additional requirements for actuating the unintended current flow prevention circuit are shown in Fig. 39. If the optional function is used, the charging/discharging station shall monitor the status of the unintentional current flow prevention circuit during the electric vehicle discharging process. If the requirements are not satisfied, the station shall transfer to shutdown sequence.

A-6.2.11 Control Circuit Supply Integrity

If an earth fault, short circuit or overcurrent is detected in the d.c. circuit of charging/discharging station, the power circuit shall be disconnected from its supplies (supply network and electric vehicle), but the power supply for control circuit shall not be interrupted.

In addition, the power supply for the control circuit of the charging/discharging station shall not be interrupted by the loss of a.c. supply to which it may be connected. In case of the loss of a.c. supply, the control functions of the charging/discharging station, including digital communication with the vehicle and protection/monitoring of the system, shall remain operational until the completion of the charging/discharging control process BDC-B'4 as defined in **A-6.3.2**.

NOTE — If a d.c. electric vehicle charging/discharging station has grid-independent operating function, means such as battery backup or an a.c. power supply for the control circuit can be implemented.

A-6.2.12 Protection against Under-Voltage at the Interface

The d.c. electric vehicle charging/discharging station shall perform an emergency error shutdown and disconnect its supply to prevent under-voltage at the battery, if output withdrawal voltage drops below minimum limit sent by the vehicle.

A-6.3 Charging/Discharging Control Process

A-6.3.1 Charging/Discharging State

Table 37 defines the charging/discharging state of d.c. electric vehicle charging/discharging station. The charging/discharging states show physical status of d.c. electric vehicle charging system. The d.c. electric vehicle charging/discharging station and the vehicle can exchange their charging state through the signal communication and the digital communication.

A-6.3.2 Charging/discharging control process and state

Table 38 defines the charging/discharging control process as system action level of d.c. electric vehicle charging/discharging station. For charging control process, see **A-4.1**.

A-6.3.3 Description of the Process During Discharging (Energy Transfer)

In this process, the vehicle continues to send the maximum available current value of discharging current or the minimum allowable voltage to the d.c. electric vehicle charging/discharging station throughout discharging process. The following algorithms shall be taken.

MCC (Maximum Current Control)

- a) The EVPS can regulate the drawn current using MCC under both electric vehicle constraints and supply network needs;
- b) The d.c. electric vehicle charging/discharging station should receive the maximum available current value the vehicle transmitted (the maximum limit), throughout the discharging control process;
- c) The d.c. electric vehicle charging/discharging station should set the control target based on the utility requirement, and regulate the d.c. discharging current within the maximum limit; and
- d) The d.c. electric vehicle charging station should regulate the d.c. discharging current responding to the change of the maximum limit of the vehicle, if the maximum limit drops below the utility requirement.

Table 37 Charging/Discharging States of d.c. EV Charging/Discharging Station
(Clause A-6.3.1)

State		Vehicle connected	Vehicle contactor	Charging/ discharging possible	Description
BDC-A	Not connected	No	Open	No	Vehicle unconnected
BDC-B1	Initialization	Yes	Open	No	Vehicle connected/not ready to accept energy/communication not established/connector unlatched or latched/vehicle contactor open
BDC-B2		Yes	Open	No	Vehicle connected/not ready to accept energy/communication established/connector unlatched or latched/vehicle contactor open
BDC-B3		Yes	Open	No	Vehicle connected/not ready to accept energy/communication established/connector latched/vehicle contactor open/other supplemental processes not completed
BDC-C	Energy transfer	Yes	Close	Yes	Vehicle connected/ready to accept or deliver energy/indoor charging area ventilation not required/communication established/connector latched/vehicle contactor close/other supplemental processes completed
BDC-D		Yes	Close	Yes	Vehicle connected/ready to accept or deliver energy/indoor charging area ventilation required/communication established/connector latched/vehicle contactor close/other supplemental processes completed
BDC-B'1	Shutdown	Yes	Close	Yes	Vehicle connected/charging or discharging finished/ communication maintained/connector latched/vehicle contactor close
BDC-B'2		Yes	Open	No	Vehicle connected/charging or discharging finished/communication maintained/connector latched/vehicle contactor open/other supplemental processes completed
BDC-B'3		Yes	Open	No	Vehicle connected/charging or discharging finished/communication maintained/connector unlatched or latched/vehicle contactor open
BDC-B'4		Yes	Open	No	Vehicle connected/charging or discharging finished/communication finished/connector unlatched or latched/vehicle contactor open
BDC-E	Error	Yes	Open	No	EVPS disconnected from vehicle/d.c. EVPS disconnected from utility, d.c. EVPS loss of utility power or control pilot short to control pilot reference.
BDC-F	Malfunction	Yes	Open	No	Other d.c. EVPS problem
NOTE—The control pilot functions can be achieved using PWM pilot control as described in Part 1 or any other system that provides the same results.					

**Table 38 Charging/Discharging Control Process of d.c.
EV Charging/Discharging Station at System action level**
(Clause A-6.3.2)

Charging/discharging control stage (process)		State	High level action a
Initialization	Handshaking	BDC-A	Vehicle unconnected
		BDC-B1	Connector plugged in
		BDC-B1	Wake up of DCCDCF and VCDCF
		BDC-B1	Communication data initialization
		BDC-B1→ BDC-B2	Communication established, parameters exchanged, and compatibility checked
	Charge/discharge preparation	BDC-B2→ BDC-B3	Connector latched
		BDC-B3	Insulation check for d.c. power line
Energy transfer		BDC-C or BDC-D	Vehicle side contactors closed
		BDC-C or BDC-D	Pre-charge
		BDC-C or BDC-D	Charging by current demand (CCC) or discharging by the maximum available current of the vehicle battery (for MCC, <i>see</i> A-6.3.3)
		BDC-C or BDC-D	Charging by voltage demand (CVC)
		BDC-C or BDC-D→ BDC-B'1	Current suppression
		BDC-C or BDC-D	Renegotiate parameter limits (option)
		Shutdown	BDC-B'1
BDC-B'1→ BDC-B'2	Welding detection (by vehicle, option)		
BDC-B'2	Vehicle side contactors open		
BDC-B'2	d.c. power line voltage verification		
BDC-B'3	Connector may be unlatched		
BDC-B'4	End of charge/discharge at communication level		
BDC-A	Connector unplugged		
a The order of actions does not refer to the procedure of charging/discharging control process.			

A-6.3.4 State Transition Diagram and Sequence Diagram

The charging/discharging process of System A shall conform to the state transition diagram as shown in Fig. 40. Fig. 41 gives the charging/discharging sequence diagram under normal conditions.

A-6.4 Additional Requirements for d.c. EV Discharging Equipment

A-6.4.1 General

d.c. electric vehicle discharging equipment specifically designed for electric vehicle discharging, for example a portable Vehicle-to-Load (V2L) power supply, shall meet the requirements in A-6.4.

A-6.4.2 Protective Earthing Conductor Under consideration

A-6.4.3 IP Degrees

The d.c. electric vehicle discharging equipment shall have IP degrees as defined in 12.4.1 of IS 17017 (Part 1) : 2018 except for the standard socket-outlet.

A-6.4.4 a.c. Leakage Current Detection Under consideration

A-6.4.5 a.c. Power Quality

The Category 0 station or equipment shall output an a.c. voltage/current waveform with a power quality specified under the regulations/norms/standards/guidelines endorsed in each country.

A-6.4.6 Connection to Household a.c. Cabling/Supply Network

The d.c. electric vehicle discharging equipment shall have a visible label on its surface and/or provide an instruction manual indicating that the connection of its a.c. output to the household a.c. cabling or supply network via a.c. mains socket-outlet or by other means is strictly forbidden.

A-7 OPTIONAL FUNCTIONS**A-7.1 General**

System A station may have some optional functions, for example dynamic control in which the available output current transmitted to an electric vehicle is dynamically controlled during the charging process.

A-7.2 Compatibility Check

System A station shall satisfy the following requirements in the charging state of initialization 1:

- a) notify the vehicle that the station is compatible with each optional function as defined in Annex A of IS 17017 (Part 24), and
- b) check that the vehicle is compatible with each optional function.

Each optional function shall be performed only if both the station and the vehicle are compatible with the optional function.

A-7.3 Dynamic Control

Station A shall satisfy the following requirements in the charging state of energy transfer:

- a) change the available output current to a designated value in a single-step process for example from 120 A to 60 A without any delay. Once the value has been increased or decreased, the station shall hold the same value for at least 10 s before changing the available output current again; and
- b) not detect any errors associated with the dynamic control within the 10 s period specified above.

In response, the vehicle will change the charging current request to a value less than or equal to the available output current with the rate of change defined in A-5. If the available output current is increased, the vehicle may also increase the charging current request up to the available output current.

Station A shall then output charging current according to the charging current request from the vehicle (see Fig. 42).

A-7.4 High Current Control

System A station shall use appropriate messages for high current control according to Annex A of IS 17017 (Part 24).

A-7.5 High Voltage Control

System A station shall use appropriate messages for high voltage control according to Annex A of IS 17017 (Part 24).

A-8 COMPLIANCE TEST FOR USER INITIATED SHUTDOWN

This test shall evaluate the behaviour of the d.c. electric vehicle supply equipment in case that the charging session is terminated by user-initiated shutdown, in accordance with the requirements in 6.3.1.110.

The test shall be performed according to the following procedure:

- a) Connect the d.c. electric vehicle supply equipment to an artificial load;
- b) Start charging with the procedure specified by charger manufacturer;
- c) Confirm that the d.c. power line between d.c. electric vehicle supply equipment and electric vehicle is energized at the rated voltage and the d.c. electric vehicle supply equipment is operating normally;
- d) Stop charging by the method specified by charger manufacturer, for example press the stop button;
- e) Check that the d.c. electric vehicle supply equipment stops charging without displaying any alarm or error information; and
- f) Confirm that the d.c. power line between d.c. electric vehicle supply equipment and electric vehicle is de-energized to 10 V or less.

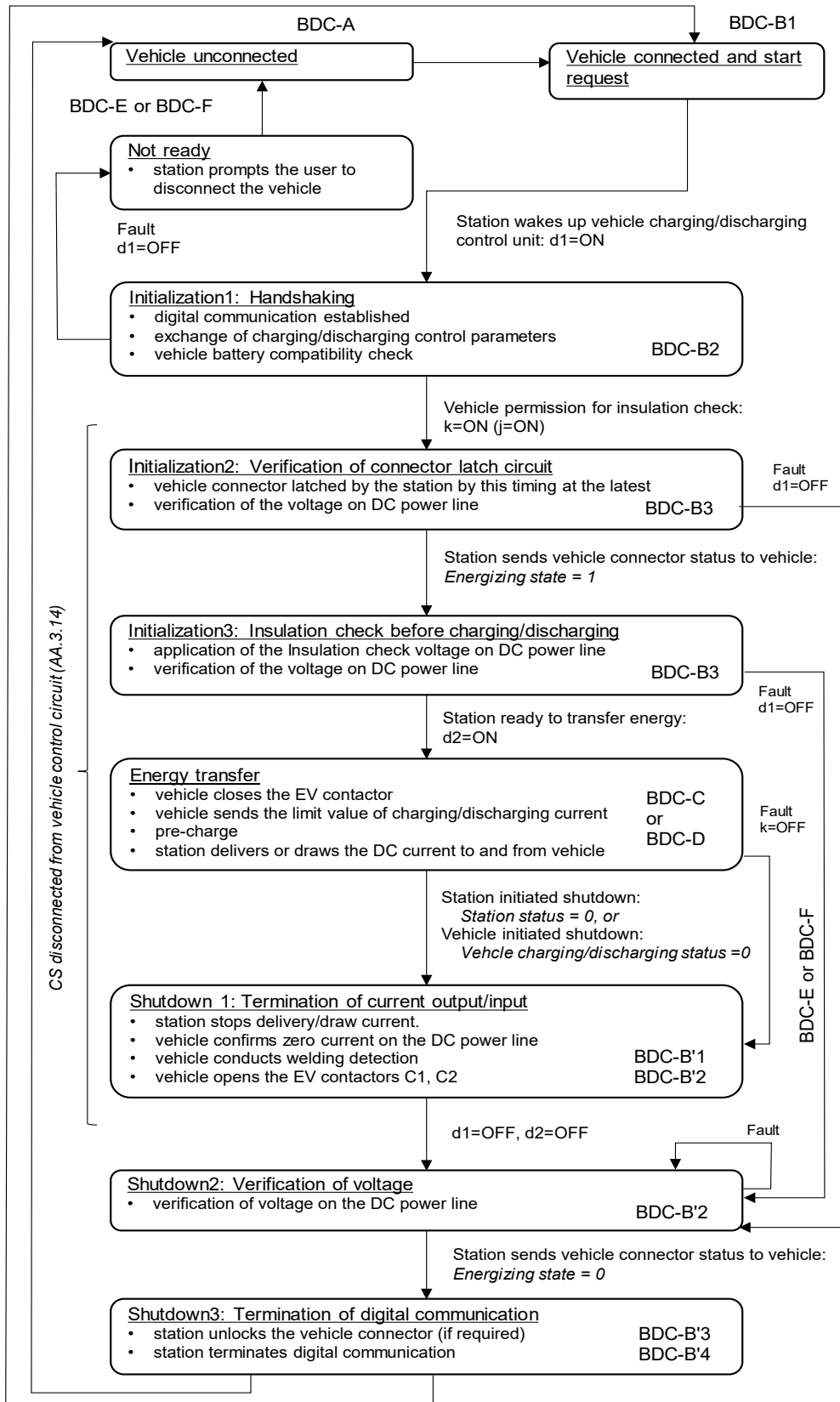
A-9 SPECIFIC REQUIREMENT FOR CHARGING WITH THERMAL MANAGEMENT SYSTEM**A-9.1 Surface Temperature of the Charging Cable**

The surface temperature of the charging cable shall not exceed the temperature rating of the insulation used or shall comply with the following requirements under the normal operating ambient temperature, whichever is less.

- a) The graspable part shall not exceed 60 °C; and
- b) The touchable part shall not exceed 85 °C.

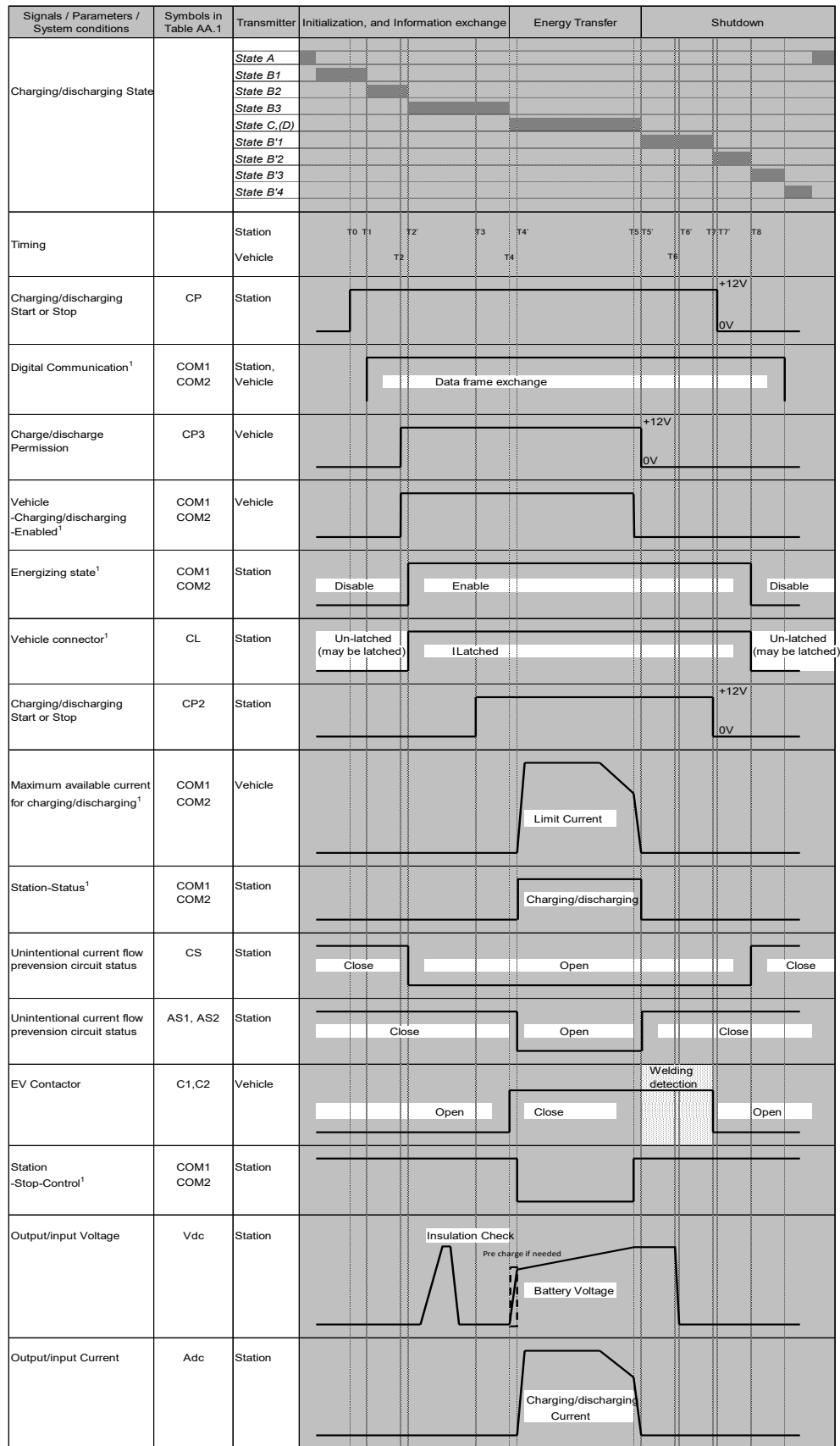
A-9.2 Functional or Performance Requirements to be Implemented for Protection Against Over-Temperature

System A shall provide one of the protection cases in Table 39 for protection against over-temperature of d.c. contact assembly of the vehicle connector and charging cable assembly according to the output current range of station. Table 40 provides the requirements of each measure in Table 39.



NOTE — Italic means the parameters exchanged via digital communications as defined in Annex A of IS 17017 (Part 24).

FIG. 40 STATE TRANSITION DIAGRAM OF CHARGING/DISCHARGING PROCESS



¹ Annex A of IS 17017 (Part 24). The station may keep the lock throughout the process as indicated by the dotted line.

FIG. 41 CHARGING/DISCHARGING SEQUENCE DIAGRAM

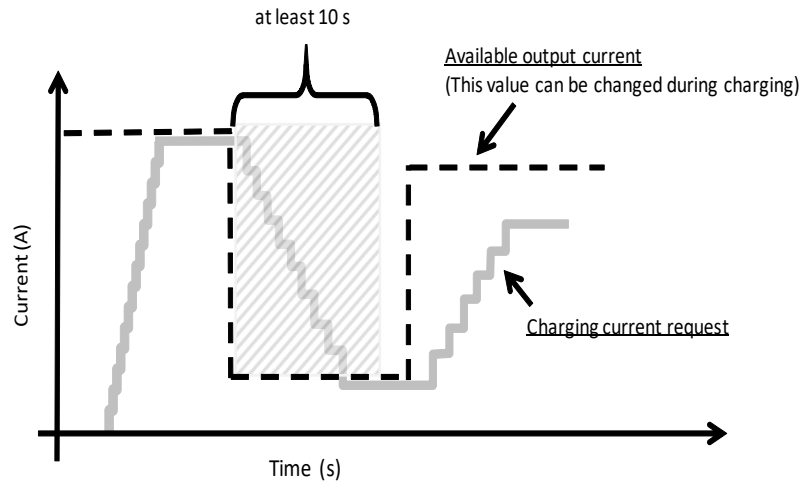


FIG. 42 TRANSITION OF AVAILABLE OUTPUT CURRENT AND CHARGING CURRENT REQUEST DURING DYNAMIC CONTROL

Table 39 Selection of Protection Measures Against Over-Temperature
(Clause A-9.2)

Output current range	Protection case	Required measures (see Table 36)			
		a	b	c	d
0-200 A	A	R	NR	R	NR
0-200 A	B1	NR	R	R	NR
0-200 A	B2	NR	R ^a	NR	R
0-400 A	C1	R	NR	NR	R
0-400 A	D1	NR	R	R	NR
0-400 A	D2	NR	R ^a	NR	R
Key R Required (mandatory) NR Not required R ^a Requirement 'b' may be omitted if a charging cable is also protected concurrently by the protective means of the vehicle coupler (requirement 'd')					

Table 40 Protection Measures Against Over-Temperature
(Clause A-9.2)

Type	Protection measures
a	A charging cable having a rated current more than or equal to the maximum current of the d.c. electric vehicle supply equipment shall be used.
b	By using either monitoring or estimating the surface temperature of the charging cable, the output current shall be limited or stopped to prevent an over-temperature. For the limitation of the output current, the dynamic control function defined in A-7 shall be applied.
c	A vehicle connector having a rated current (specified by each connector manufacturer) more than or equal to the maximum current of the d.c. electric vehicle supply equipment shall be used.
d	By monitoring the temperature of both the P and N terminals of the vehicle connector, with a temperature sensor or an equivalent means ¹ , the output current shall be reduced or stopped to prevent an over-temperature. For the limitation of the output current, the dynamic control function defined in A-7 shall be applied.
¹ Example of an equivalent means: a vehicle connector with a function to open the latch circuit (for example temperature fuse, relay) in case the terminal temperature exceeds the design limit value	

A-9.3 Marking

If the surface temperature of the charging cable is expected to exceed 60 °C under certain condition, a warning label should be attached on the cable as shown in Fig. 43.

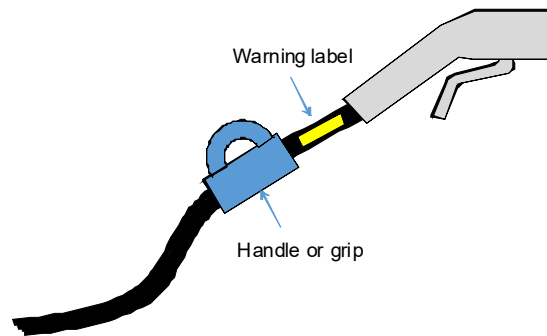


FIG. 43 EXAMPLE OF WARNING LABEL

ANNEX B

(Clause 1, 6.3.1.116 and 7.1.101)

d.c. EV SUPPLY EQUIPMENT OF SYSTEM C

B-1 GENERAL

This annex provides specific requirements for d.c. electric vehicle supply equipments for use with System C (here in after also referred to as “d.c. charger”). System C is a mode 4 charging system. The maximum system output voltage shall be limited to 1 000 V d.c. or less dependent on the components of the system.

Table 41 d.c. Couplers for Combined Charging System
(Clause B-1)

Sl No.	d.c. couplers for combined charging system
a)	Configuration FF according to IS 17017 (Part 2/Sec 3) : 2020.
b)	Autoconnect Charging Device (see IEC 61851-23-1 (under preparation))

B-2 COMMUNICATION

The general definitions and functions of the proximity pilot (PP) and control pilot (CP) – signals/contacts are according to IS 17017 (Part 1) : 2018 (including detailed resistor definitions in Table 41 and Table 42) with the specific resistor value for configuration FF given in Table 42. A CP duty cycle of 5 percent shall be used according Annex A of IS 17017 (Part 1) : 2018.

Table 42 Definition of Proximity Resistor for Configuration FF
(Clause B-2)

Proximity Resistor (Rc as per IS 17017 (Part 1) : 2018)	Maximum current for a.c. charging	d.c. connector
1 500 W	not applicable	Configuration FF

Charge control communications between the d.c. electric vehicle supply equipment and the electric vehicle shall comply with IS 17017 (Part 24).

The physical layer for charge control communications shall comply with IS/ISO 15118-3.

Contact assignments of the different connectors are in IS 17017 (Part 2/Sec 3) : 2020.

Charge control communications shall comply with DIN SPEC 70121. Charge control communications shall also comply with IS/ISO 15118-2.

For automatic connection systems, the proximity pilot function is not required and communication can be carried out on a wireless physical layer, according to ISO 15118-6, ISO 15118-7 and IS/ISO 15118-8.

The interface circuit of Fig. 44 shall be used for configuration FF.

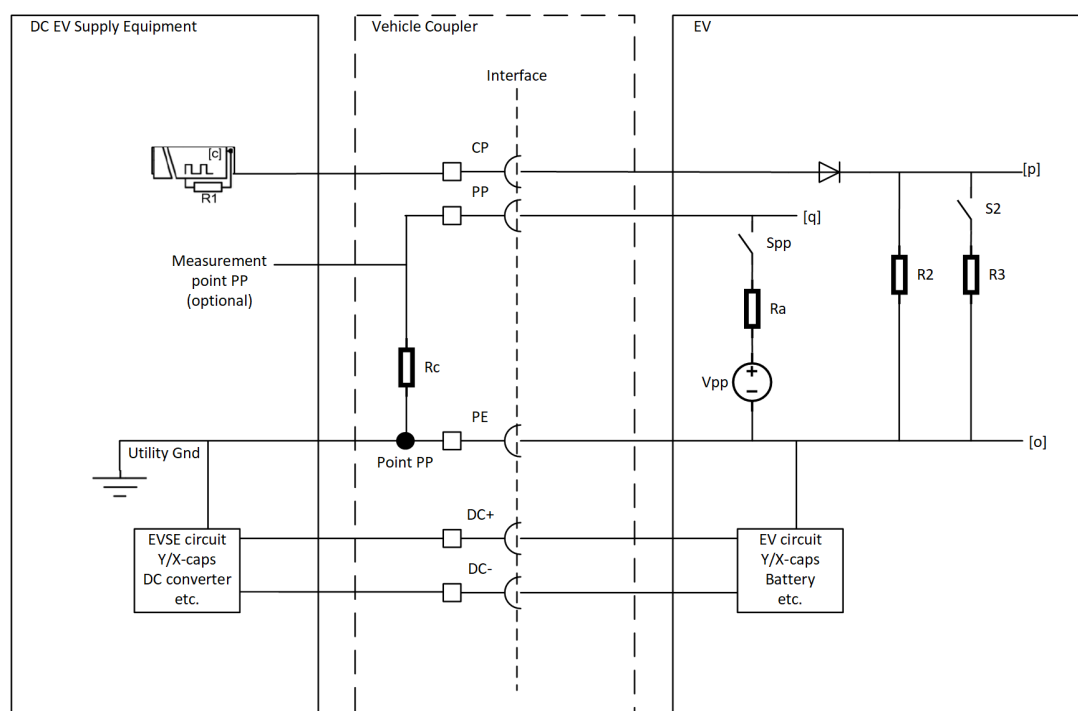


FIG. 44 INTERFACE COMPONENTS FOR CONFIGURATION FF

The switch S_{pp} is optional for the electric vehicle to implement depending on its strategy to detect PE loss (see B-4.9).

B-3 PROCESS OF ENERGY SUPPLY

B-3.1 General

The process of supplying energy to the electric vehicle by the d.c. electric vehicle supply equipment is initiated and controlled by the messages sent over HLC and shall follow the sequences shown in Fig. 46, Fig. 47, Fig. 48 and Fig. 49. For normal start up, normal shutdown, d.c. electric vehicle supply equipment and electric vehicle initiated error shutdown, d.c. electric vehicle supply equipment initiated error or emergency shutdown and electric vehicle initiated error shutdown. Electric Vehicle Initiated error shutdown shall also comply with the requirements of DIN SPEC 70121.

The messages described in DIN SPEC 70121:2014 and IS/ISO 15118-2 : 2014 are abbreviated in the sequence diagrams with numbers (see Table 43).

Example of charging sequence and description are shown in Fig. 45 and Table 47.

B-3.2 Normal Start Up

Sequence diagram and description for normal start up are shown in Fig. 46 and Table 45.

B-3.3 Normal Shutdown

Sequence diagram and description for normal shutdown are shown in Fig. 47 and Table 46.

After the completion of normal shutdown, the electric vehicle shall not induce voltages above the values specified in 6.3.1.115.

Table 43 Message Mapping for Sequence Diagram

(Clause B-3.1)

Phase	Message No.	DIN Spec 70121 : 2014/ IS/ISO 15118-2 : 2014
Data-link	SLAC	SLAC messages
Initialization	SDP	sdp messages
	0a	supportedAppProtocolReq
	0b	supportedAppProtocolRes
	1a - Xa	The electric vehicle messages requests concerning session setup, services, authentication, payment options and value added services (if supported by the negotiated application layer protocol).
	1b - Xb	The EVSE messages respond concerning session setup, services, authentication, payment options and value added services (if supported by the negotiated application layer protocol).
	3a	ChargeParameterDiscoveryReq
	3b	ChargeParameterDiscoveryRes
Insulation Check & Pre-Charge	4a	CableCheckReq
	4b	CableCheckRes
	5a	PreChargeReq
	5b	PreChargeRes
	6a	PowerDeliveryReq
	6b	PowerDeliveryRes
Energy Transfer	7a	CurrentDemandReq
	7b	CurrentDemandRes
	8a	PowerDeliveryReq
	8b	PowerDeliveryRes
Welded Check & Unlocking	9a	WeldingDetectionReq
	9b	WeldingDetectionRes
	10a	SessionStopReq
	10b	SessionStopRes

Table 44 Example of Sequence Description
(Clause B-3.1)

Timestamp	Description: Explanation charge sequence
► ta	• Events executed before reaching ta.
ta	• Events that shall be executed at ta.
	• The events executed at this timestamp shall be completed before reaching the next timestamp.
ta ► tb	• Events that shall be executed between ta and tb.
	• The events inside a timeframe (between ta and tb) shall be executed in any order and completed before reaching the next timestamp if they do not have a time constraint (indicated with within).
	• If the event within a timeframe has a time constraint (within), then tb is the moment that this event is executed.
tb ►	• Events that shall be executed from tb onwards in any order

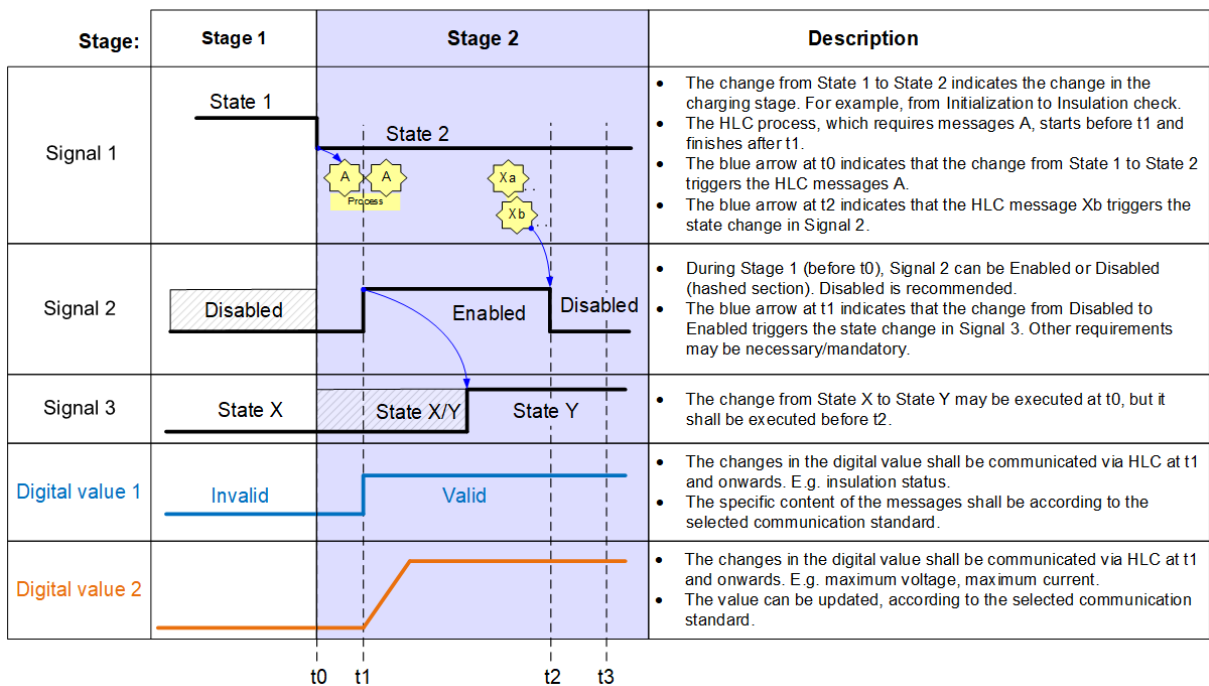


FIG. 45 EXAMPLE CHARGING SEQUENCE

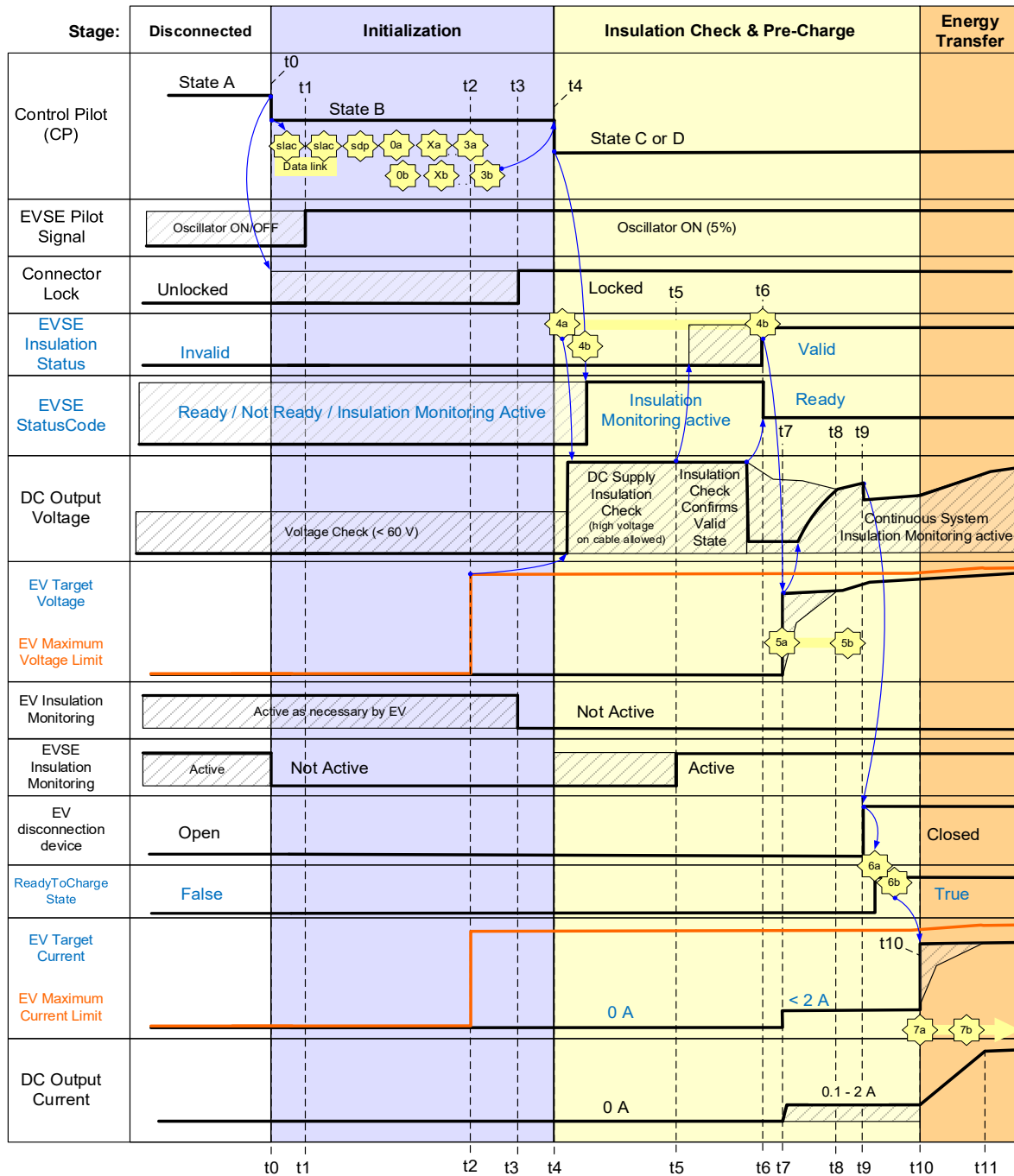


FIG. 46 SEQUENCE DIAGRAM FOR NORMAL START UP

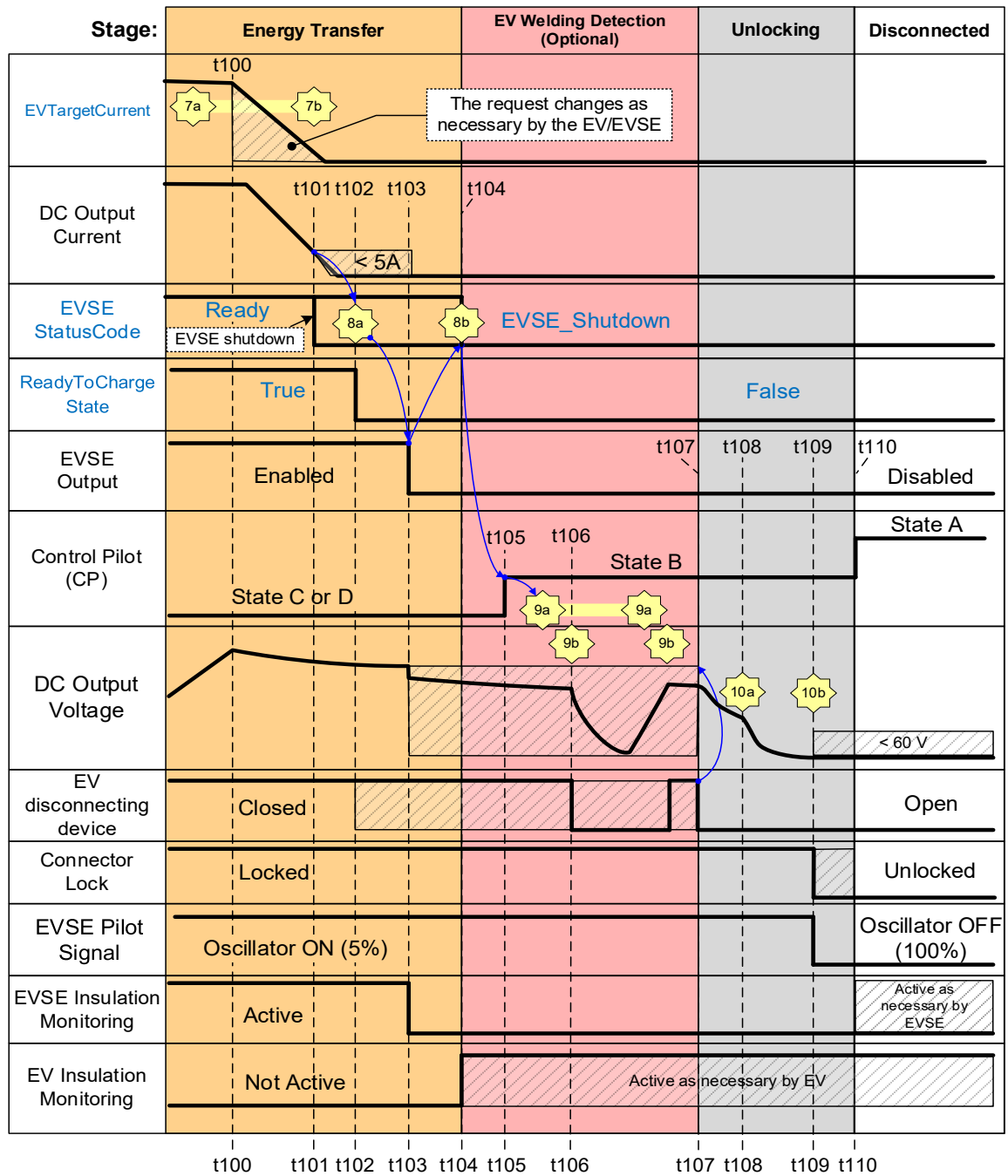


FIG. 47 SEQUENCE DIAGRAM AND DESCRIPTION FOR NORMAL SHUTDOWN BY EV/EVSE

Table 45 Sequence Description for Normal Start Up
(Clause B-3.2)

Timestamp	Sequence description for normal start up
► t0	- The EVSE shall check if the d.c. output voltage is less than 60 V and shall not allow to start a supply session if 60 V is exceeded. <i>See B-4.5.</i> - The vehicle connector is plugged into the electric vehicle inlet, which changes the CP state from A to B.
t0	- After the CP state changed to B, the electric vehicle may lock the vehicle connector in its inlet. - After the CP state changed to B, the EVSE Insulation Monitoring device shall stop. - After the CP state changed to B, the electric vehicle may try to set up a data link as defined in IS 17017 (Part 24).
t1	- The EVSE shall turn on its CP oscillator if the EVSE is ready to charge and if it not already turned on. - The electric vehicle shall establish the data link as defined in the IS 17017 (Part 24) after it has verified that the EVSE has turned on its CP oscillator.
t1 ► t2	- High level communication (V2G) starts by the negotiation of an appropriate application layer protocol between the electric vehicle <0a> and EVSE <0b>. - The electric vehicle and EVSE exchange messages pairs concerning session setup, services, authentication, payment options and value added services (if supported by the negotiated application layer protocol).
t2	- The electric vehicle sends its electric vehicle Maximum Voltage limit and electric vehicle Maximum Current limit (amongst other parameters) for d.c. supply output current and voltage with ChargeParameterDiscoveryReq <3a>. - The minimum and maximum values of the EVSE are sent to the electric vehicle with ChargeParameterDiscoveryRes <3b>. - The EVSE shall check if the d.c. output voltage is less than 60 V and shall trigger an error shutdown if 60 V is exceeded. <i>See B-4.5.</i>
t2 ► t3	- The compatibility check is performed by the EVSE. The result (Response Code = “OK” or “FAILED_WrongChargeParameter”) and status (“EVSEProcessing” = ‘Ongoing’ or ‘Finished’) shall be sent to the electric vehicle with ChargeParameterDiscoveryRes <3b>. - After alignment of all parameters, the EVSE responds with Parameter “EVSEProcessing” = ‘Finished’ in ChargeParameterDiscoveryRes <3b>. - If the electric vehicle and EVSE are not compatible, then the electric vehicle shall not go to Ready and will transfer to step t107 in the normal shutdown sequence.
t3	- The electric vehicle shall lock the vehicle connector in its inlet before changing the CP to state C or D. - The electric vehicle shall stop its insulation monitoring device, if any.
t4	- After the electric vehicle has stopped its insulation monitoring device and after checking that the vehicle connector is locked, the electric vehicle changes the CP state from B to C/D by closing S2. - After checking that the vehicle connector is locked, The electric vehicle requests cable and insulation check before pre-charge with CableCheckReq <4a>. <i>See Cable check B-4.1.3.</i>
t4 ► t5	- The EVSE checks if the CP state changed to state C or D before sending the first CableCheckRes <4b> message and before applying a voltage higher than 60V on the d.c. Output. - The EVSE checks the insulation of the d.c. Output and continuously reports the insulation state with the parameter “EVSE insulation status” in CableCheckRes<4b>.
t5	The EVSE determines that the insulation resistance of the d.c. Output is $\geq 100 \text{ k}\Omega$.
t5 ► t6	After having successfully finished the insulation check, the EVSE indicates with parameter “EVSE insulation status”=‘Valid’ in subsequent messages, starting with CableCheckRes <4b>
t6	The EVSE shall send the result of the cable check by changing the parameters “EVSE StatusCode” to “Ready” and “EVSEProcessing” to ‘Finished’ in CableCheckRes <4b>.
t6 ► t7	- The EVSE may keep the voltage on the d.c. output. - Pre-charge starts when the electric vehicle sends PreChargeReq <5a>, which contains the requested d.c. current $\leq 2 \text{ A}$ (maximum inrush current according to B-6.2) and the requested d.c. voltage. <i>See Pre-charge (B-5.1).</i>
t7	During pre-charge, the EVSE shall be able to supply a d.c. output current as defined in B-5.1, limit the output current to 2A (<i>see B-6.2</i>) and ignore the current request of the electric vehicle.
Timestamp	Sequence description for normal start up
t7 ► t8	The EVSE adapts the d.c. output voltage to the requested value in <5a> and sends the corresponding PreChargeRes <5b>.
t8	- The d.c. output voltage reaches the voltage requested by the electric vehicle within the tolerances given in section 101.2.2. - The electric vehicle may adapt the requested d.c. output voltage with cyclic messages PreChargeReq <5a> (<i>See Note in B-5.1</i>).
t8 ► t9	NOTE — To obtain an inlet voltage within the $\pm 20\text{V}$ of the battery voltage, the electric vehicle can adjust the pre-charge voltage request to compensate for tolerances and steady state errors.

Table 45 (Concluded)

Timestamp	Sequence description for normal start up
t9	The electric vehicle shall close its disconnection device only after verifying that the absolute voltage difference between the electric vehicle inlet and the electric vehicle battery is less than 20 V (See 9.2 in ISO 17409). NOTE — The electric vehicle should be protected against the case that the polarity of the d.c. output is reversed.
t9 ► t10	- The electric vehicle sends PowerDeliveryReq <6a> with “ReadyToChargeState”=‘True’ to enable the electric vehicleSE Output. - After disabling the pre-charge circuit, if any, and switching ON its power supply output, the EVSE communicates that it is Ready for energy transfer with PowerDeliveryRes <6b>.
t10	- During charging, the EVSE continuously monitors the insulation of the d.c. Output (See B-4.1.4). - The electric vehicle sets the electric vehicleTargetCurrent with CurrentDemandReq <7a> to start the energy transfer phase. - The EVSE adapts its d.c. output current and voltage to the requested values in CurrentDemandReq <7a>. - The EVSE reports the following information to the electric vehicle with CurrentDemandRes<7b>: - Its present d.c. output current and voltage, - Its present limits for d.c. output current and voltage, and - Its present status. NOTE — Electric vehicle may change its d.c. current and voltage request even if the d.c. output current has not reached the values in the previous request.
t10 ► t11	
t11	The d.c. output current reaches the d.c. output current request within the time delay (Td) defined in 101.2.3.
t11 ►	The electric vehicle adapts its d.c. current and voltage request according to its charging strategy with cyclic CurrentDemandReq <7a> messages.

Table 46 Sequence Description for Normal Shutdown
(Clause B-3.3)

Timestamp	Sequence description for normal shutdown by EV/EVSE
► t100	- Cyclic CurrentDemand messages between the electric vehicle <7a> and EVSE <7b> - If the electric vehicle wants to stop a charge session for a non-critical reason, it shall reduce the current request <7a> to terminate the energy transfer. Reduction is done on electric vehicle charging strategy. - If the EVSE wants to stop a charge session for a non-critical reason, it shall: - ramp down the output current, and - adjust its maximum output current (EVSEMaxCurrentLimit), which is communicated to the electric vehicle, according to this, in order to inform the electric vehicle that the d.c. output current will reduce. NOTES - This informs the electric vehicle that the d.c. output current is being reduced. - Legacy vehicles might directly go to t101 without reducing the current request. This will be interpreted as an electric vehicle-initiated error shutdown by the EVSE (see “EV error shutdown table”)
t100	
t100 ► t101	The d.c. output current shall decrease to less than 5 A and remain below 5 A.
t101	When the d.c. output current is below 5 A, the next CurrentDemandRes <7b> message, shall set the Parameter EVSE StatusCode to “EVSE_Shutdown” if the EVSE wants to stop the charge session.
t102	The electric vehicle requests the EVSE to disable its output by sending message PowerDeliveryReq <8a> with ReadyToChargeState set to False.
t102 ► t104	- The electric vehicle may open its disconnection device after the d.c. output current is below 5 A and after the message <8a> has been sent. - The EVSE shall disable its output and open its disconnection device, if any.
t103	- The EVSE Insulation Monitoring device shall be disabled. - The EVSE shall start to actively discharge any internal capacitance on its output. - The EVSE shall not discharge the electric vehicle with more than 0.15 A (see B-5.5.1 “0A mode”) - The EVSE reports “EVSE Status Code”=‘EVSE_Shutdown’ with message <8b>, to indicate it has disabled its output.
t104	The electric vehicle may activate its insulation monitoring device, if any. NOTE — The common mode and differential mode influences from the EVSE should be removed before sending the message <8b>.

Table 46 (Concluded)

Timestamp	Sequence description for normal shutdown by EV/EVSE
t105	The electric vehicle changes CP state to B after receiving message <8b>. NOTE — If the electric vehicle decides not to perform welding detection, it proceeds with t107.
t105 ► t106	The electric vehicle sends initial welding detection request <9a>.
t106	- The electric vehicle may perform its welding detection check after receiving message WeldingDetectionRes <9b>. - electric vehicle may actuate its disconnection device to perform welding detection.
t106 ► t107	- The electric vehicle may send multiple <9a> requests in order to read the d.c. supply output voltage measured by the EVSE in the response message <9b>. - The electric vehicle completes welding detection, if performed.
t107	The electric vehicle shall open its disconnection device. NOTE — This starts the reduction of the d.c. output voltage by passive discharge.
t108	- The electric vehicle shall send the SessionStopReq <10a> message when it has confirmed that its disconnection device is open. - The SessionStopReq <10a> message initiates termination of HLC through PLC. - The EVSE shall start to reduce the d.c. output voltage to less than 60 V within 1s and remain below 60 V.
t108 ► t109	The EVSE shall send the message SessionStopRes <10b>.
t109	The EVSE shall turn off its CP oscillator according to IS 17017(Part 24)
Timestamp	Sequence description for normal shutdown by EV/EVSE
	- The electric vehicle shall only unlock the connector if the d.c. output voltage is below 60 V. - The electric vehicle should wait to receive message SessionStopRes <10b> before unlocking. NOTES
t109 ► t110	1 If digital communication according to IS/ISO 15118 is used, the EV may request a pause according to IS/ISO 15118-2:2018. If supported by the EVSE, the EV can wake up the EVSE and re-initiate a charging session (see B-5.2). The communication session will re-start after the wake up process. 2 If the EVSE is ready for re-initiation of a new charging session, use the sequence described in B-5.2.
t110	Disconnecting of vehicle connector changes CP state from B to A.

B-3.4 Error and Emergency Handling

d.c. electric vehicle supply equipment and electric vehicle shall have means to initiate error or emergency shutdowns.

NOTE — Error Shutdown is to prevent damage to the equipment. While Emergency Shutdown is to protect the user from a hazardous situation.

During an error or emergency shutdown, the electric vehicle shall open its disconnection device within 100 ms after the EVSE has turned off its CP oscillator or the electric vehicle has triggered the emergency shutdown.

Table 47 gives an overview of the error and emergency shutdown cases defined in this standard.

B-3.5 d.c. EV Supply Equipment and EV Initiated Error Shutdown

Sequence diagrams and descriptions for d.c. electric vehicle supply equipment and electric vehicle initiated error shutdown are shown in Fig. 48 and Table 48.

During an error shutdown, the electric vehicle could enter the welding detection phase and perform a welding detection if the HLC support this and is available (see **B-4**).

Table 47 Overview of Error and Emergency Shutdown Cases
(Clause B-3.4)

Cases for error shutdown	Cases for emergency shutdown
- message sequence error	- CP loss reaction (B-4.3)
- cable check errors (B-4.1.3)	- Overcurrent protection (B-6.5)
- Insulation monitoring during charging (B-4.1.4)	- Continuous continuity checking of the protective conductor (6.3.1.2)
- Protection against overvoltage between positive terminal d.c.+ and negative terminal DC- at the interface (6.3.1.106)	- control circuit supply integrity (6.3.1.108)
- Load dump (101.2.7)	- Maximum voltage between DC+/- and protective conductor in conditions with a single earth fault (6.3.1.113)
- Overtemperature handling (101.4.2.2)	- Short-circuit protection (13.101)
- Check of the plausibility of the values provided by the thermal sensing (101.4.2.3)	- if error shutdown doesn't work properly

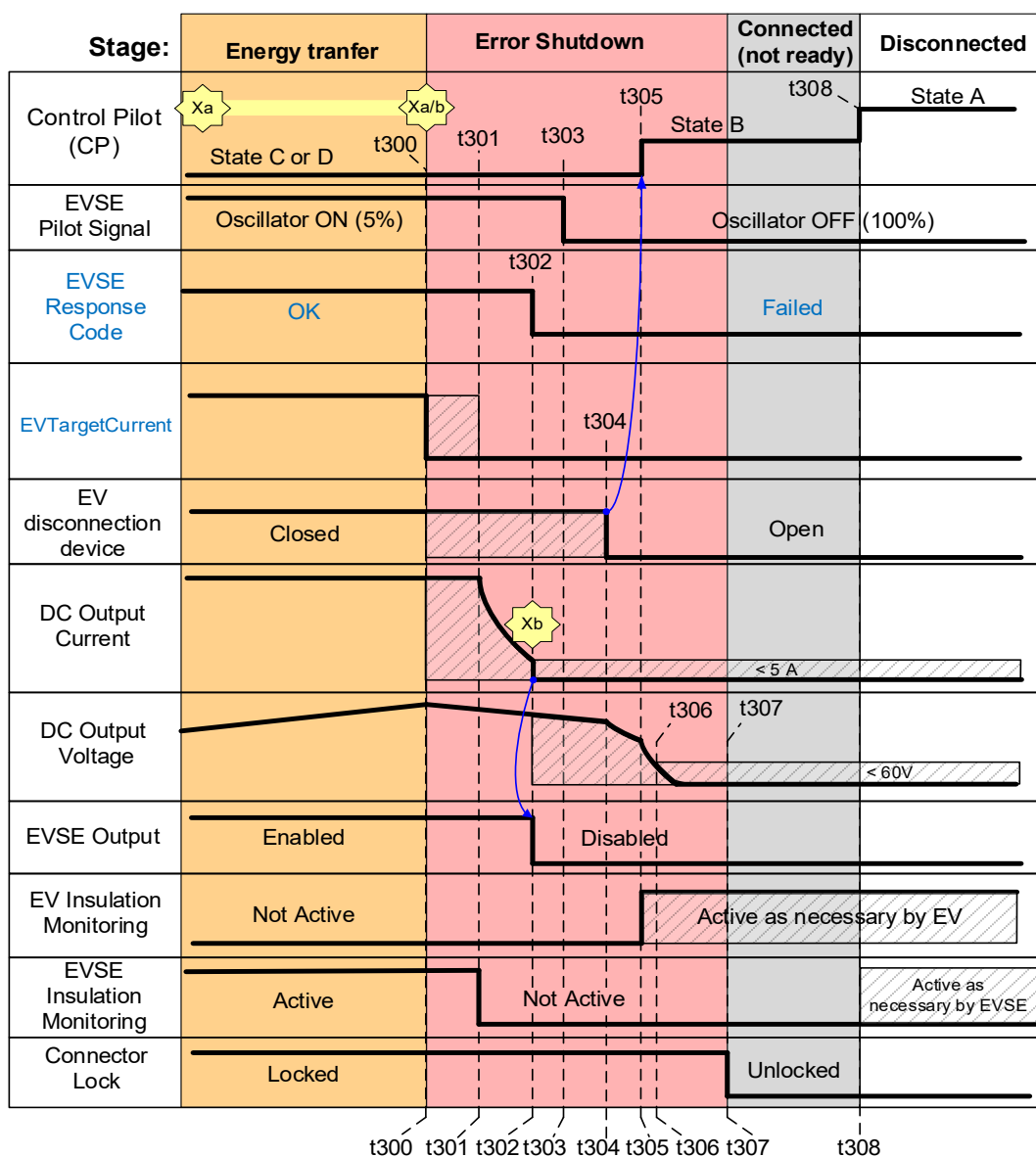


FIG. 48 SEQUENCE DIAGRAM FOR D.C. EV SUPPLY EQUIPMENT AND EV INITIATED ERROR SHUTDOWN

After the completion of an error shutdown, the electric vehicle shall not induce voltages above the values specified in 6.3.1.116.

B-3.6 d.c. EV Supply Equipment AND EV Initiated Emergency Shutdown

Sequence diagrams and descriptions for d.c. electric vehicle supply equipment and electric vehicle initiated

emergency shutdown are shown in Fig. 49 and Table 49.

After the completion of an emergency shutdown, the electric vehicle shall not induce voltages above the values specified in 6.3.1.117.

NOTE — The electric vehicle cannot enter the welding detection phase nor can it perform a welding detection based on voltages above the values specified in 6.3.1.117.

Table 48 Sequence Description For d.c. EV Supply Equipment and EV Initiated Error Shutdown
(Clause B-3.5)

Timestamp	Sequence description for Error Shutdown for any stage by EVSE or by EV (Excluding Table 46)
► t300	- General pre-condition: High Level Communication messages between the electric vehicle <Xa> and EVSE <Xb> . - Preconditions for electric vehicle initiated error shutdown: CP state B, C or D. - Preconditions for EVSE initiated error shutdown: CP Oscillator ON.
t300	- Occurrence of error shutdown condition detected by the electric vehicle or EVSE (for example the electric vehicle triggers an error shutdown via HLC, communication loss or closing of the data link or TCP connection). - The trigger time starts from this moment. - The electric vehicle may open its disconnection device (for the electric vehicle-initiated error shutdown). NOTES - Error Shutdown is to prevent damage to the equipment. - The trigger time for electric vehicle initiated error shutdown depends on communication requirements.
t301	- The EVSE performs the error shutdown. - The timing requirements of 6.3.1.116 (performance time) starts from this moment. - The EVSE shall disable its insulation monitoring device.
t301 ► t302	The EVSE shall reduce its d.c. output current to less than 5A and disable its output within 1s.
t301 ► t306	- The EVSE shall, within 2.5 s: - reduce the d.c. output voltage to less than 60 V between DC+ and DC-; and - reduce the d.c. output voltage to less than 28 V between DC+ and earthing terminal, and between DC- and earthing terminal.
t302	- The d.c. output current shall be less than 5A and remain at less than 5A. - The EVSE shall disable its output. - EVSE initiated Error Shutdown: - The EVSE shall send ResponseCode 'Failed' in the next response messages (<i>see</i> IS 17017(Part 24)) - Electric vehicle initiated Error Shutdown if the HLC is still operational (<i>see</i> IS/ISO15118-2 for the exception case): - The EVSE shall reply with message SessionStopRes <10b> (<i>see</i> DIN 70121).
t302 ► t303	The EVSE shall turn off its CP oscillator within 200ms
t303	- The EVSE is turning off its CP oscillator NOTES - Turning off the CP oscillator without sending a message <Xb> containing a 'Failed' ResponseCode will trigger an Emergency Shutdown (<i>See</i> 6.3.1.117). The delay of 200ms should be sufficient for the electric vehicle to receive this message - If the EVSE has not turned OFF its CP oscillator 1 s after the Error Shutdown has started (t300), the electric vehicle and EVSE shall trigger an Emergency Shutdown. <i>See</i> 6.3.1.117. for the timing requirements for the EVSE regarding d.c. output current, disconnection device and oscillator.
t303 ► t304	The electric vehicle shall open its disconnection device within 100 ms after the EVSE has turned off its CP oscillator.
t304	The electric vehicle is opening its disconnection device.
t305	- The electric vehicle shall change the CP state to B when it has opened its disconnection device. - The electric vehicle may activate its insulation monitoring device.
t306	- The d.c. output voltage shall be: - less than 60 V between DC+ and DC- ; and - less than 28 V between DC+ and PE, and between DC- and PE. NOTE — The d.c. output voltages shall be at these values 2.5 s after the Error Shutdown was triggered at t300. <i>See</i> 6.3.1.116. for the timing requirements for the EVSE regarding d.c. output voltage.
t307	The electric vehicle shall not unlock the connector unless the d.c. output voltage has dropped below 60 V. (<i>See</i> 6.3.1.103)
t308	Disconnecting of vehicle connector changes CP state from B to A.

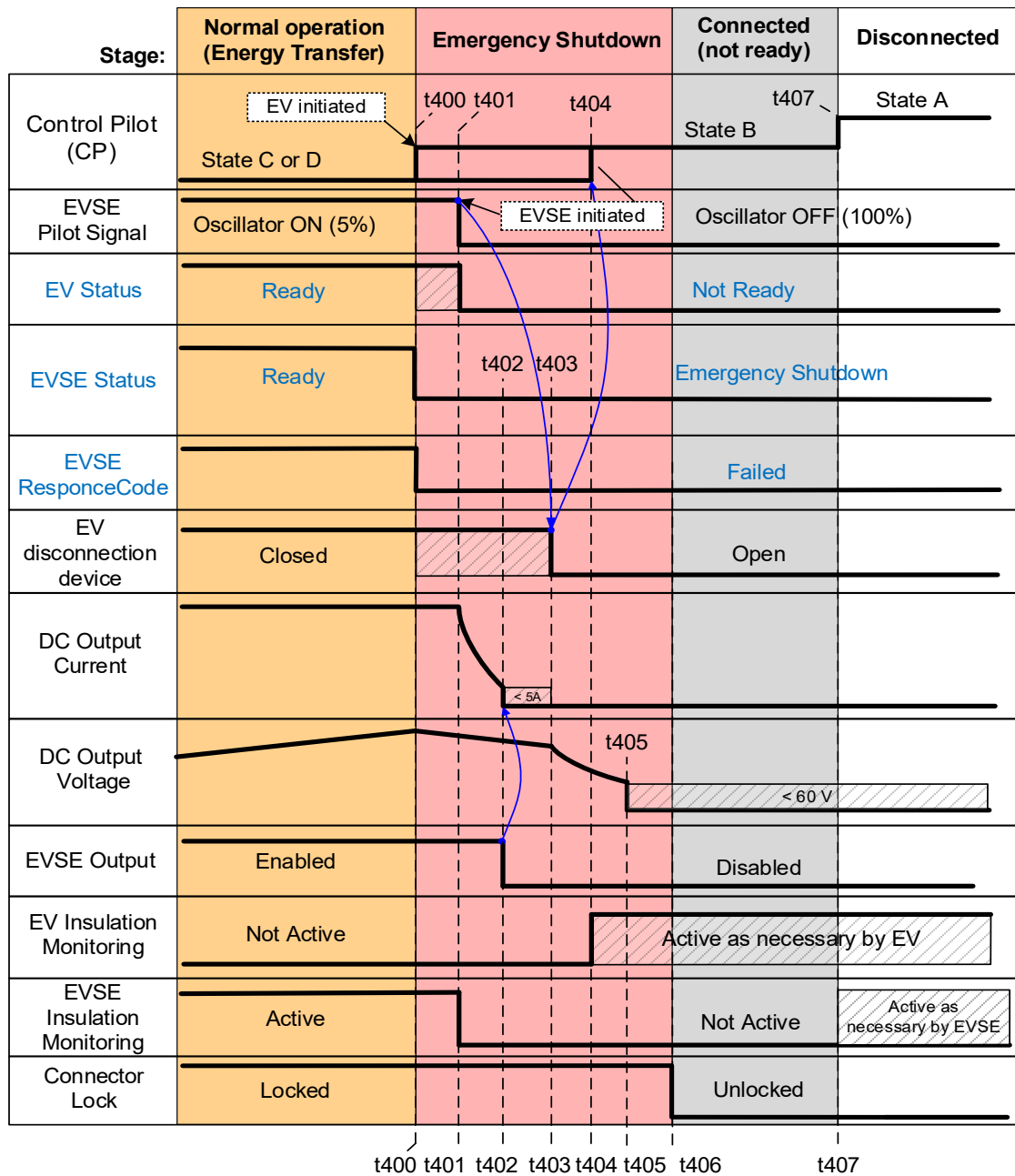


FIG. 49 SEQUENCE DIAGRAM FOR D.C. EV SUPPLY EQUIPMENT AND EV INITIATED EMERGENCY SHUTDOWN

Table 49 Sequence Description for D.c. EV Supply Equipment and EV Initiated Emergency Shutdown
(Clause B-3.5)

Timestamp	Sequence description for Emergency Shutdown by EV or EVSE
► t400	- General pre-condition: High Level Communication messages between the electric vehicle <Xa> and EVSE <Xb>. - Pre-condition for EVSE-initiated emergency shutdown: CP oscillator on - Pre-condition for electric vehicle-initiated emergency shutdown: CP state C/D - Occurrence of emergency shutdown condition (for example the CP state changes from C/D to state B or A/E/F/invalid, PE loss).
t400	NOTES 1 Emergency Shutdown is to protect the user from a hazardous situation 2 Emergency shutdown initiated by the electric vehicle is performed by changing CP state from C/D to B - The trigger time starts from this moment. - The electric vehicle may open its disconnection device (for the electric vehicle-initiated emergency shutdown).
t400 ► t401	- The EVSE shall turn off its CP oscillator within the trigger time - The EVSE is turning off its CP oscillator which indicates an Emergency Shutdown.
t401	NOTE — The timing requirements of 6.3.1.117 (performance time) start from this moment. The EVSE shall disable its insulation monitoring device.
t401 ► t402	The EVSE shall reduce its d.c. output current to less than 5 A and disable its output within 30 ms.
t401 ► t403	The electric vehicle shall open its disconnection device within 100 ms after the CP oscillator is turned off or if it detected an “occurrence of the emergency shutdown condition”
t401 ► t404	- The electric vehicle shall go to CP state B within 100 ms after the CP oscillator is turned off or if it detected an “occurrence of the emergency shutdown condition” - The EVSE shall, within 1 s: - reduce the d.c. output voltage to less than 60 V between DC+ and DC-; and - reduce the d.c. output voltage to less than 28 V between DC+ and earthing terminal, and between DC- and earthing terminal.
t401 ►	- Both the electric vehicle and EVSE may try to keep communicating if possible - If the electric vehicle or EVSE send a message, then it shall send a ‘Failed’ ResponseCode
t402	- The EVSE has reduced its d.c. output current to less than 5 A. - The EVSE shall disable its output
t403	Latest point in time the electric vehicle disconnection device is opened.
t404	- For EVSE-initiated emergency shutdown: The electric vehicle shall change the CP state to B to indicate that the electric vehicle opened its disconnection device. - The electric vehicle may activate its insulation monitoring device, if any. - The d.c. output voltage shall be: - less than 60V between DC+ and DC- ; and - less than 28V between DC+ and PE, and between DC- and PE.
t405	
t406	The electric vehicle shall not unlock the connector unless the d.c. output voltage has dropped below 60 V.
t407	Disconnecting of vehicle connector changes CP state from B to A.

B-4 SAFETY MEASURES

B-4.1 IT(Isolated Terra) System Requirements

B-4.1.1 General

The secondary circuit (output side) of the d.c. electric vehicle supply equipment shall be designed as an IT system and protection measures in accordance with 411 of IEC 60364-4-41 : 2005 shall be applied.

An insulation monitoring device (IMD) according to IEC 61557-8 or equivalent shall be used to perform insulation monitoring between DC+ and PE as well as DC- and PE during supply process and communicate the current state (Valid, Fault) of the system periodically to the electric vehicle.

The d.c. electric vehicle supply equipment shall react according to Table 50.

Table 50 Insulation states and d.c. EV supply equipment reaction based on the measured insulation resistance

(Clause B-4.1.1)

Condition 1	Condition 2	Insulation state	d.c. EV supply equipment reaction
Above 150 kΩ	Above 300 kΩ	Valid	Allow Charging
From 100 kΩ to 150 kΩ	From 100 kΩ to 300 kΩ	Valid or Fault	Allow charging or error shutdown
Below 100 kΩ	Below 100 kΩ	Fault	Error shutdown

Condition 1: External insulation resistance at the d.c. output either between DC+ and PE or between DC- and PE (but not at the same time).
Condition 2: External insulation resistance at the d.c. output both between DC+ and PE as well as between DC- and PE (at the same time).

B-4.1.2 Functional Test of Insulation Monitoring Device

The functionality of the insulation monitoring device (IMD) shall be tested during the functional test of the IMD, for example by actuating a test device or by inserting a defined test resistor.

The functional test of the IMD shall detect if the IMD is connected to the d.c. output conductors (DC+/DC-) and protective earth (PE) and that the IMD is capable of measuring the insulation resistances between DC+ and PE and DC- and PE.

The functional test of the IMD shall not deteriorate the IMD.

NOTE — During the functional test of the IMD, the requirements of 12.5 are applicable.

The functional test of the IMD shall be executed and finished during the cable check phase.

The functional status of the IMD can be as follows:

- Unknown: Functional test of the IMD has not been executed yet. In this state charging shall not be allowed.
- OK: After the functional test of the IMD has been passed the station shall go into the OK state.
- Failed: The functional test of the IMD has failed. In this state, entering the pre-charge phase shall not be allowed.

NOTES

1 The purpose of this functional test of the IMD is to check whether the insulation monitoring device is capable of fulfilling its monitoring function on the d.c. output of the d.c. electric vehicle supply equipment and not to check if the insulation of the system is below a certain threshold. By checking the measurement connections of the IMD to the system conductors and to earth, the complete measurement circuit of the IMD can be tested.

2 During the activation of the functional test of the IMD, the response time of the insulation monitoring device can be extended as long this does not happen during the energy transfer stage.

Compliance is checked by design review.

B-4.1.3 Cable Check

Prior to each pre-charge phase a cable check has to be performed. During the cable check, the d.c. electric vehicle supply equipment shall apply on the d.c. output the lower value of the following two voltages:

- 110 percent of the maximum voltage communicated by the electric vehicle to the EVSE during initialization phase; and
- Maximum output voltage of the d.c. electric vehicle supply equipment.

Requirements for protection against overvoltage at the interface according to 6.3.1.106 do not apply during cable check.

The d.c. electric vehicle supply equipment shall perform a short circuit detection according to 6.3.1.109 during the cable check phase.

During the cable check, the d.c. electric vehicle supply equipment shall limit the output current to a maximum of 5 A.

The d.c. electric vehicle supply equipment may perform a welding detection during the cable check phase. If the d.c. electric vehicle supply equipment performs a welding detection, then it shall still comply with the requirements of 6.3.1.112 and 6.3.1.113.

NOTE — The electric vehicle should take care not to be influenced by the common mode influences which the d.c. electric vehicle supply equipment can produce during its welding detection.

The functional test of the IMD (see B-4.1.2) shall be executed and finished during the cable check phase.

During cable check the insulation resistance shall be continuously monitored. The insulation states can be as follows:

- Invalid: The functional test of the IMD (see B-4.1.2) has not resulted in the OK state

and/or the IMD has not finished the measurement of the insulation resistance. The d.c. electric vehicle supply equipment shall trigger an error shutdown if the IMD remains in invalid state until the end of the cable check phase;

- b) Valid: The measured insulation resistance between DC+/DC- and PE is above or equal to a value of 100 k Ω (without negative tolerance);
- c) Fault: The measured insulation resistance between DC+/DC- and PE is below a value of 100 k Ω (without negative tolerance). The d.c. electric vehicle supply equipment shall trigger an error shutdown before or at the end of the cable check phase and send a fault message to electric vehicle if necessary according to IS 17017 (Part 24);
- d) In order to fulfil the timing requirements of the digital communication according to IS 17017 (Part 24), the EVSE shall be able to detect a valid state within V2G_SECC_CableCheck_Performance (= 38 s according to IS/ISO 15118).

Compliance is checked by **B-9.3.16.1**.

B-4.1.4 Insulation Monitoring During Charging

During charging the insulation resistance of the system shall be continuously monitored. The insulation states can be as follows:

- a) Valid: The measured insulation resistance between DC+/DC- and PE is above or equal to a value of 100 k Ω (without negative tolerance); and
- b) Fault: The measured insulation resistance between DC+/DC- and PE is below a value of 100 k Ω (without negative tolerance). The d.c. electric vehicle supply equipment shall trigger an error shutdown within 10 s and send a fault message to electric vehicle if necessary according to IS 17017 (Part 24).

NOTES

1 The d.c. electric vehicle supply equipment can issue an optical and/or acoustical signal to the user.

2 The electric vehicle takes responsibility for the time coordination of its IMD. Prior to closing its electric vehicle disconnection devices (cf. time t_7 in Fig. 46.) the electric vehicle either turns off its IMD or it is guaranteed that no interference with the station's IMD occurs.

Compliance is checked by **B-9.3.16.2**.

B-4.2 Combined Coupler Latching Function

For all types of d.c. connectors according to Table 41, the vehicle inlet shall provide a latching function to mitigate unintentional disconnecting of the vehicle connector from the vehicle inlet during energy supply.

Requirement for latching function is stated in ISO 17409.

B-4.3 CP Loss Reaction

When an unintended transition from CP state C/D to state B/A, any other or an unknown state occurs, the d.c. electric vehicle supply equipment and the electric vehicle shall trigger an emergency shutdown within 10 ms.

B-4.4 Voltage Check At Initialization

At beginning of supply session, with CP state A or B, the d.c. electric vehicle supply equipment shall check if voltage on the cable is less than 60 V and shall terminate supply session if 60 V is exceeded.

B-4.5 d.c. EV Supply Equipment Maximum Output Y Capacitance

The maximum total parallel Y capacitance shall not exceed 1 μ F. This implies ≤ 500 nF Y capacitance across each d.c. rail and ground for a d.c. electric vehicle supply equipment with Y capacitance equally distributed between each d.c. rail and ground.

B-4.6 Minimum Cross-Sectional Area of Protective Conductor

The minimum cross-sectional area of the protective conductor shall be 6 mm².

B-4.7 Leakage and Charge Limitation of Touch Current

The d.c. electric vehicle supply equipment shall limit the steady-state leakage current and the charge to DC-2 according to IEC 60479-1, and C1 according to IEC 60479-2, in accordance with **8.102.4**.

The following shall be considered to meet the requirements above:

- a) a human body impedance of 500 Ω ;
- b) the maximum y-capacitances of the electric vehicle according ISO 17409; and
- c) a worst-case asymmetric leakage resistance of the electric vehicle where charging is still possible.

Compliance is verified using a calculation, for instance using the following example (see Fig. 50, Fig. 51 and Table 51) or an equivalent simulation or measurement.

B-4.8 PE Loss Reaction

The d.c. electric vehicle supply equipment shall trigger an emergency shutdown within 70 ms if a loss of electrical continuity of the protective conductor occurs anywhere from the inside of the d.c. electric vehicle supply equipment up to the point PP (see Fig. 44).

The electric vehicle shall monitor the electrical continuity of the protective conductor from point PP to the electric vehicle by doing the following:

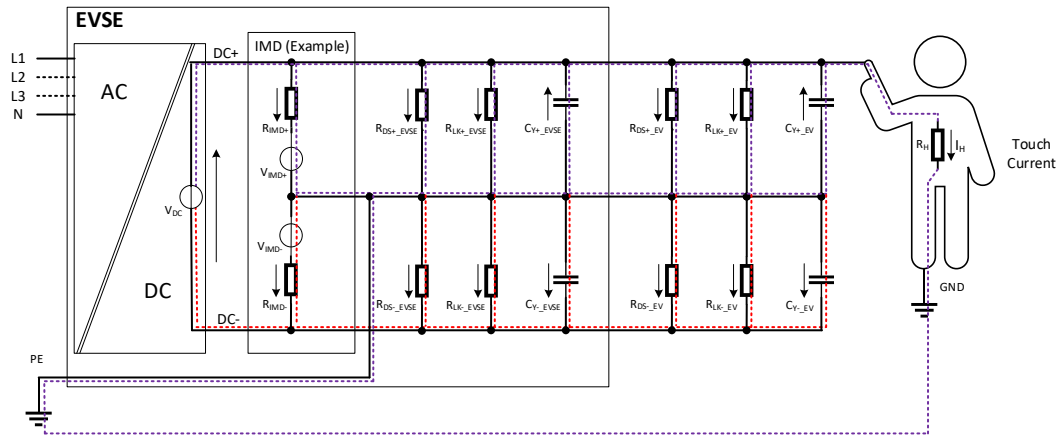


FIG. 50 CIRCUIT DIAGRAM WITH COMPONENTS INFLUENCING THE TOUCH CURRENT

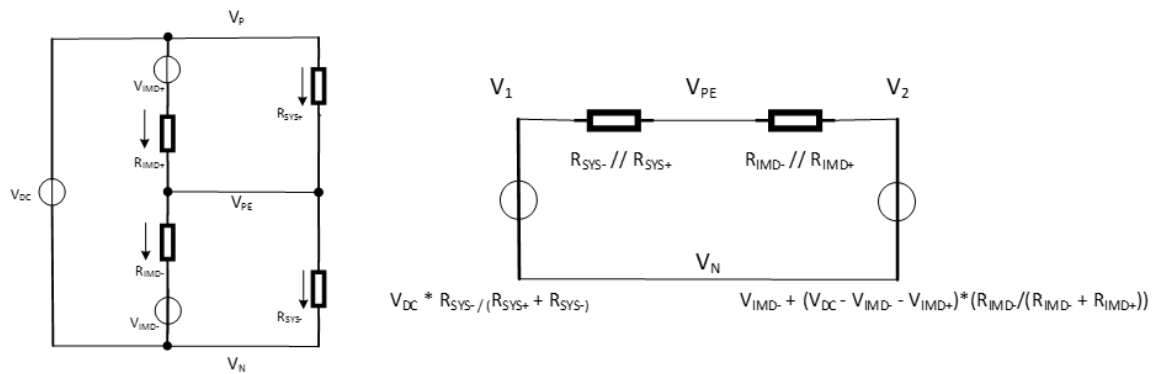


FIG. 51 EQUIVALENT CIRCUITS FOR EXAMPLE IN FIG. 50

Table 51 Exemplary determination if touch current limit is fulfilled by design
(Clause B-4.8)

Vdc	Maximum output voltage		920	V	
Vimd+	IMD measurement voltage		50	V	
Vimd-	IMD measurement voltage	=-Vimd+	-50	V	
Rimd+	IMD measurement resistance		120000	Ω	
Rimd-	IMD measurement resistance		120000	Ω	
Rds+_EVSE	Designed resistance EVSE +		1000000	Ω	
Rds-_EVSE	Designed resistance EVSE -		1000000	Ω	
Rlk+_EVSE	Leakage resistance EVSE +		1000000	Ω	
Rlk-_EVSE	Leakage resistance EVSE -		1000000	Ω	
Rds+_EV	Designed resistance EV +		1000000	Ω	
Rds-_EV	Designed resistance EV -		1000000	Ω	
Rlk+_EV	Leakage resistance EV +		1000000	Ω	
Rlk-_EV	Leakage resistance EV -		100000	Ω	
Rh	Human body representation		500	Ω	
Cy+EV	Y capacitance EV +		2.00E-06	F	
CY-EV	Y capacitance EV -		2.00E-06	F	
Cy+EVSE	Y capacitance EVSE +		5.00E-07	F	

Table 51 (Concluded)

CY-EVSE	Y capacitance EVSE -		5.00E-07	F	
Ctot	Total Y capacitance system	$= C_y + C_{EV} + C_{Y-EVSE}$	5.00E-06	F	
Rsys+	System resistance +	$= 1 / ((1/R_{ds+EVSE}) + (1/R_{lk+EVSE}) + (1/R_{ds+EV}) + (1/R_{lk+EV}) + (1/R_h))$	499	Ω	
Rsys-	System Resystance -	$= 1 / ((1/R_{dc-EVSE}) + (1/R_{lk-EVSE}) + (1/R_{ds-EV}) + (1/R_{lk-EV}))$	76923	Ω	
Rsys+nh	Rsys+ without human	$= 1 / ((1/R_{ds+EVSE}) + (1/R_{lk+EVSE}) + (1/R_{ds+EV}) + (1/R_{lk+EV}))$	250000	Ω	
Rsys	Total system resistance	$= 1 / ((1/R_{sys+}) + (1/R_{sys-}))$	495.785	Ω	
Rimd	Total IMD resistance	$= 1 / ((1/R_{imd+}) + (1/R_{imd-}))$	60000	Ω	
Rsys_nh	Rsys without human	$= 1 / ((1/R_{sys+nh}) + (1/R_{sys-}))$	58823.5	Ω	
V1	Thevenin equiv. V1	$= V_{dc} * (R_{sys-} / (R_{sys+} + R_{sys-}))$	914.07	V	
V2	Thevenin equiv. V2	$= V_{imd-} + (V_{dc} - V_{imd-} - V_{imd-}) * (R_{imd-} / (R_{imd+} + R_{imd-}))$	410	V	
V1_nh	V1 without human	$= V_{dc} * (R_{sys-} / (R_{sys+nh} + R_{sys-}))$	216.470	V	
Vpe	Vpe vs VDC-	$= V_2 + (V_1 - V_2) * (R_{imd} / (R_{sys} + R_{imd}))$	909.939	V	
Vpe_nh	Vpe withouth human	$= V_2 + (V_1 - V_2) * (R_{imd} / (R_{sys\_nh} + R_{imd}))$	312.277	V	
Ih	Steadystate body current	$= (V_{dc} - V_{pe}) / R_h$	0.02012	A	25 mA, Max
Ipk	Peak body current	$= (V_{dc} - V_{pe\_nh}) / R_h$	1.21544	A	
Ipk_rms	RMS body current	$= I_{pk} / \sqrt{6}$	0.49620	A	0.5 A Max, for >4 ms, See Fig. 20 of IEC 60479-2
T3RC	Duration of impulse	$= 3 * (1 / ((1/R_{sys}) + (1/R_{imd}))) * C_{tot}$	7.38E-03	s	
E	Energy through body	$= ((V_{dc} - V_1 - V_{pe\_nh})^2 - (V_{dc} - V_1)^2) * 0.5 * C_{tot}$	1.24	J	

- The electric vehicle shall check before each initiation of charging the PP circuit for correct values, this includes the continuity of the PE from the point PP up to the electric vehicle; and
- The electric vehicle shall either open switch Spp when it changes the CP state from B to C or the electric vehicle shall check the PP circuit during charging and in case of a PE loss, the electric vehicle shall trigger an emergency shutdown within 70 ms.

B-5 ADDITIONAL FUNCTIONS

B-5.1 Pre Charging

While executing the pre-charge sequence, the EVSE shall comply with the pre-charge request process as stated in the communication protocol but the current request of the electric vehicle shall be ignored and the output current shall be limited to 2 A.

During pre-charge, the EVSE shall:

- be able to pre-charge the circuit defined in Fig. 52 with the values according to Table 52 for its entire operating range within 3 s; and subsequently
- follow the voltage request from the electric vehicle according to **101.2.2.2** and **101.2.6** within 1 s.

During pre-charge, the electric vehicle shall limit its current draw to an equivalent of the circuit defined in Fig. 52 and Table 52.

This is needed to charge all the elements within the d.c. bus of the EVSE and electric vehicle connection (Y Caps, cable caps, and other components).

According to ISO 17409, the electric vehicle shall close its disconnection device only after verifying that the absolute voltage difference between the electric vehicle inlet and the electric vehicle battery is less than 20 V.

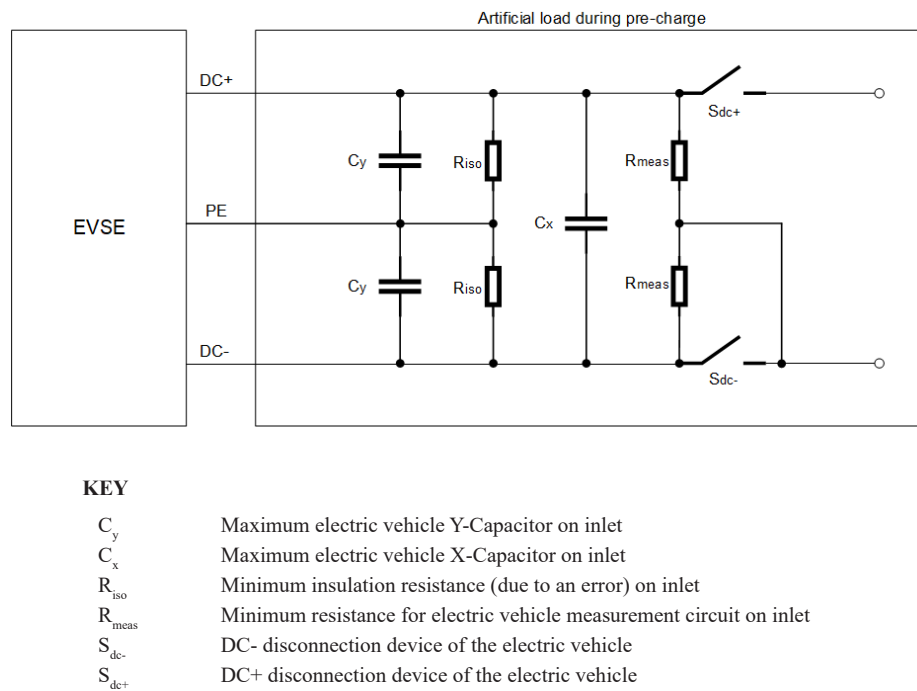


FIG. 52 WORST CASE EQUIVALENT CIRCUIT FOR THE EV DURING THE PRE-CHARGE PROCESS

Table 52 Values To Design the EV and EVSE During Pre-Charge Based on Fig. 52
(Clause B-5.1)

Symbol	Value used by EVSE	Value used by Electric Vehicle
C_y	2 μ F	$\leq 2 \mu$ F
C_x	10 nF (tbc)	≤ 10 nF
R_{iso}	≥ 100 k Ω	See ISO 17409
R_{meas}	500 k Ω	≥ 500 k Ω
S_{dc-}	closed	
S_{dc+}	open	

The electric vehicle should be protected against the case that the polarity of the d.c. output is reversed and shall not close its disconnection device.

The electric vehicle shall measure the d.c. bus voltage at its inlet and could use the measured voltage as feedback for the pre-charge request adjustments.

The electric vehicle shall not solely use the voltage measurements communicated by the EVSE to check if the EVSE output and battery voltages are within this limit. As the voltage across the electric vehicle contactors are leading for closing the electric vehicle contactors.

Fig. 53 shows the schematics for the voltage measurement points.

The electric vehicle could consider to do pre-charge voltage request adjustment to compensate for tolerances and steady state errors to get the inlet voltage within ± 20 V of the battery voltage.

Compliance is checked by **B-9.3.13**

B-5.2 Wake Up

The d.c. electric vehicle supply equipment may support a sleep mode according to IS/ISO 15118-3 : 2015 to minimize power consumption as described as an optional function in **6.3.2.101**.

The d.c. electric vehicle supply equipment may enter a sleep mode, if:

- a) the vehicle attached to the d.c. electric vehicle supply equipment has not changed the control pilot from state B2 to C2 or D2 for more than 2 min without the occurrence of any communication-based timeout; and
- b) the vehicle commands a paused V2G charging session according to 8.4.2 of IS/ISO 15118-2 : 2018.

During sleep mode the PWM oscillator shall be off while CP voltage is set to constant voltage (CP state x1) in order to allow:

- a) waking up the d.c. electric vehicle supply equipment by the electric vehicle using B1 – C1 – B1 toggling according to IS/ISO 15118-3. After

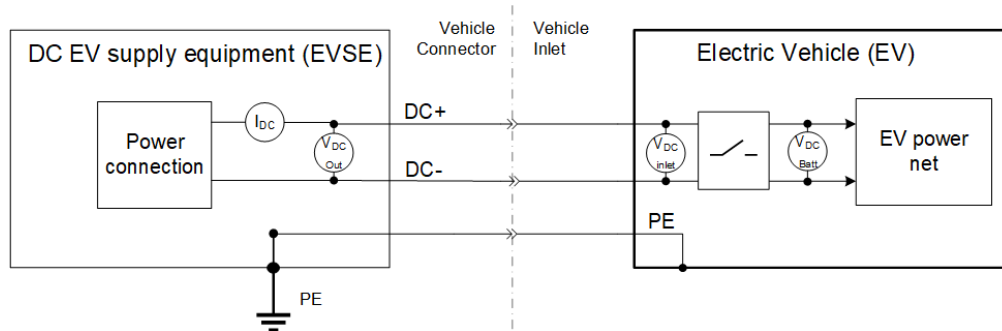


FIG. 53 VOLTAGE MEASUREMENT POINTS FOR THE PRE-CHARGE PROCESS

a successful wake up, the d.c. electric vehicle supply equipment shall enable the PWM oscillator with a duty cycle of 5 percent; and

- b) waking up the electric vehicle by the d.c. electric vehicle supply equipment using B1 – B2 change, according to Table A-6 sequence and 3.1 of Annex A of IS 17017 (Part 1) : 2018, If the d.c. electric vehicle supply equipment has turned off its CP oscillator then it shall stay in B1 for at least 3 s according to Table A-6 sequence 9.2 of Annex A of IS 17017 (Part 1) : 2018. After a successful wake up, the electric vehicle resumes digital communication. The d.c. electric vehicle supply equipment may additionally consider **A-5.3** of IS 17017 (Part 1) : 2018 (Information on difficulties encountered with some legacy electric vehicles for wake-up after a long period of inactivity).

Compliance is checked by **B-9.3.2**.

B-5.3 Handling of operating ranges

B-5.3.1 0A Mode During Energy Transfer

If the d.c. electric vehicle supply equipment cannot deliver any current, it shall send 0A as its maximum output current limit to the electric vehicle within the next communicated message. The 0A mode initiated by the d.c. electric vehicle supply equipment shall not trigger an immediate shutdown by the electric vehicle. The electric vehicle should continue the charging session for at least 5 minutes.

If the electric vehicle requests 0A or the d.c. electric vehicle supply equipment is limited to 0A, then the d.c. electric vehicle supply equipment shall reduce and maintain its d.c. output current to below 0.15 A with a minimum of –0.15 A, to prevent reverse power flow from the electric vehicle to the d.c. electric vehicle supply equipment. See **B-5.3.5** regarding the 0A request from the electric vehicle.

NOTE — The 0A mode is used to temporarily charge without current being delivered. For example: when there are power fluctuations in the electric grid, or there is no power available.

B-5.3.2 Changing Maximum Output Current

The d.c. electric vehicle supply equipment is allowed to deliver less current than the requested current by the electric vehicle if its maximum output current limit is below the electric vehicle current request.

The d.c. electric vehicle supply equipment shall communicate the change of maximum output current limit in the next communicated message.

B-5.3.3 Changing Maximum Output Power

The d.c. electric vehicle supply equipment is allowed to deliver less current than the current requested by the electric vehicle if the d.c. electric vehicle supply equipment's maximum output power limit drops below the present output power delivered to the electric vehicle.

The EVSE shall communicate the change of the maximum output power limit in the next communicated message.

B-5.3.4 d.c. EV supply equipment delivers less current than EV current request

If the d.c. electric vehicle supply equipment delivers less current than the target current request from the electric vehicle, this shall not result in a shutdown triggered by the electric vehicle.

NOTE — This decrease in output current can be caused by grid dips, CVC mode or a change in maximum output current. See **B-5.3.2**.

B-5.3.5 EV Requests a Current below d.c. EV Supply Equipment Minimum Output Current

The d.c. electric vehicle supply equipment shall go into 0A mode (see **B-5.3.1**), as if the electric vehicle requested 0A, when the d.c. electric vehicle supply equipment receives a current request below its minimum output current.

$$I_{EVSE\_Out} = 0 \text{ if } I_{EV\_Req} < I_{EVSE\_Min}$$

where

I_{EVSE_Out} : Output current of the d.c. electric vehicle supply equipment.

I_{EVSE_Min} : Minimum output current limit of the d.c. electric vehicle supply equipment.

I_{EV_Req} : Target current request from the electric vehicle

B-5.3.6 *EV Requests a Current above d.c. EV Supply Equipment Maximum Output Current*

The d.c. electric vehicle supply equipment shall continue the charge session with its maximum output current or the maximum current from the electric vehicle, whichever is less, if the electric vehicle requests a current higher than these maximum current limits:

$$I_{EVSE\_Out} = \begin{cases} \text{MIN}(I_{EV\_MAX}, I_{EVSE\_MAX}) \\ \text{if } I_{EV\_req} > \text{MIN}(I_{EV\_MAX}, I_{EVSE\_MAX}) \end{cases}$$

where

I_{EVSE_Out} : Output current of the d.c. electric vehicle supply equipment

I_{EVSE_MAX} : Maximum output current from the d.c. electric vehicle supply equipment

I_{EV_MAX} : Maximum input current from the electric vehicle

I_{EV_req} : Target current request from the electric vehicle

B-5.3.7 *Output Voltage d.c. EV Supply Equipment Higher than Maximum Output Voltage*

The d.c. electric vehicle supply equipment shall trigger an error shutdown within 10 ms if the measured output voltage is equal or higher than the maximum output voltage of the d.c. electric vehicle supply equipment for more than 400 ms

Error Stop if $V_{EVSE\_measured} \geq V_{EVSE\_MAX}$ for more than 400 ms

where

$V_{EVSE\_Measured}$: Output voltage measured by the d.c. electric vehicle supply equipment

V_{EVSE_MAX} : Maximum output voltage of the d.c. electric vehicle supply equipment

B-5.3.8 *Output Voltage of d.c. EV Supply Equipment is below its Minimum Output Voltage*

The d.c. electric vehicle supply equipment shall trigger an error shutdown within 10 ms if the measured output voltage or the requested output voltage by the electric vehicle is lower than the minimum output voltage of

the d.c. electric vehicle supply equipment for more than 3 s.

Error Stop if $\text{MIN}(V_{EVSE\_measured}, V_{EV\_req}) < V_{EVSE\_MIN}$ for more than 3 s

where

$V_{EVSE\_Measured}$: Output voltage measured by the d.c. electric vehicle supply equipment

V_{EVSE_MIN} : Minimum output voltage of the d.c. electric vehicle supply equipment

V_{EV_Req} : Target voltage request from the electric vehicle

NOTE — This case could be detected during the pre-charge stage, as the d.c. electric vehicle supply equipment cannot supply the correct voltage for pre-charge.

B-5.3.9 *EV Requests a Voltage above the Maximum Voltage Limits*

The d.c. electric vehicle supply equipment shall continue the charge session with the maximum output voltage if the electric vehicle requests a voltage higher than the maximum output voltage of the d.c. electric vehicle supply equipment.

The d.c. electric vehicle supply equipment shall continue to charge with the requested output voltage from the electric vehicle or the d.c. electric vehicle supply equipment's maximum output voltage, whichever is less, if the electric vehicle requests a voltage higher than the maximum battery voltage:

$$V_{EVSE\_Out} = \text{MIN}(V_{EV\_Req}, V_{EVSE\_Max}) \quad \text{if } V_{EV\_req} > V_{EV\_Max}$$

where

V_{EVSE_Out} : Output voltage of the d.c. electric vehicle supply equipment

V_{EVSE_Max} : Maximum output voltage of the d.c. electric vehicle supply equipment.

V_{EV_Req} : Target voltage request from the electric vehicle

V_{EV_Max} : Maximum battery voltage of the electric vehicle

NOTE — The d.c. electric vehicle supply equipment can remain in CCC mode until the maximum battery voltage is reached. See overvoltage protection in **6.3.1.106**, which prevents overcharging the electric vehicle battery.

B-5.3.10 *Limitations due to Minimum Power*

The d.c. electric vehicle supply equipment shall go into 0A mode (see **B-5.3.1**), as if the electric vehicle requested 0A, if:

- the requested power by the electric vehicle is below the minimum output power of the d.c. electric vehicle supply equipment; or

- b) for more than 3 s, the measured output voltage multiplied by the requested output current is below the minimum output power of the d.c. electric vehicle supply equipment.

$$I_{EVSE\_Out} = 0 \text{ if } P_{EV\_Req} < P_{EVSE\_MIN}, \text{ or}$$

$$I_{EVSE\_Out} = 0$$

if $V_{EVSE\_Measured} * I_{EV\_Req} < P_{EVSE\_MIN}$ for more than 3s

where

I_{EVSE_Out} : Output current of the d.c. electric vehicle supply equipment

I_{EV_Req} : Target current requested by the electric vehicle

$V_{EVSE\_Measured}$: Output voltage measured by the d.c. electric vehicle supply equipment

P_{EV_Req} : Power requested by the electric vehicle

P_{EVSE_MIN} : Minimum power output of the d.c. electric vehicle supply equipment

NOTE — P_{EVSE_MIN} is the internal minimum power that the d.c. electric vehicle supply equipment can deliver, as this value is not handled by the communication, but is restricting the output. The d.c. electric vehicle supply equipment cannot know the minimum and actual battery voltages as these are not communicated through HLC.

B-5.3.11 Limitations due to Maximum Power

If the electric vehicle requests a power output or current multiplied by the measured voltage that is higher than the power limits of the electric vehicle or d.c. electric vehicle supply equipment, then the d.c. electric vehicle supply equipment shall continue the charge session and limit its output power to the minimum of the following values:

- Electric vehicle maximum power, and
- d.c. electric vehicle supply equipment maximum power output

$$P_{EVSE\_out} = \min(P_{EV\_MAX}, P_{EVSE\_MAX}),$$

$$\text{if } \min(V_{EVSE\_measured} * I_{EV\_req}, P_{EV\_req}) > \min(P_{EV\_MAX}, P_{EVSE\_MAX})$$

where

$V_{EVSE\_Measured}$: Output voltage measured by the d.c. electric vehicle supply equipment

I_{EV_Req} : Target current requested by the electric vehicle

P_{EVSE_out} : Output Power delivered by the d.c. electric vehicle supply equipment

P_{EVSE_MAX} : Maximum power output of the d.c. electric vehicle supply equipment

P_{EV_Req} : Power requested by the electric vehicle

P_{EV_MAX} : Maximum Power requested by the electric vehicle

NOTE — According to IS/ISO 15118-2, the PEV_Req is the electric vehicle Maximum Power Limit within the CurrentDemand messages and the PEV_MAX is the electric vehicle MaximumPowerLimit communicated.

B-6 SPECIFIC REQUIREMENTS

B-6.1 Turn on Inrush Current (d.c. Output)

Any inrush current on d.c. output in both directions when closing of electric vehicle disconnection device and d.c. electric vehicle supply equipment contactors, if any, shall be limited by the d.c. electric vehicle supply equipment to 2 A, for example by applying a pre-charging circuit as shown in Fig. 48.

NOTE — Higher current values for short time under 1 ms can appear for charging and discharging of cable capacitance.

B-6.2 Requirements for Load Dump

In any case of load dump, voltage overshoot shall not exceed 110 percent of the maximum voltage limit of the vehicle, as communicated during the initialisation phase, or maximum voltage limit of the vehicle, as communicated during the initialisation phase, + 50 V whichever is higher. (see 101.2.7)

If the electric vehicle battery gets disconnected from the d.c. output during charging, the electric vehicle shall perform an error shutdown before re-initiating charging.

B-6.3 d.c. Output Current Regulation

When in current regulation mode, the d.c. electric vehicle supply equipment shall provide direct current to the vehicle. The maximum allowable error between the output current and the target current requested by the vehicle is:

- ± 150 m A when the commanded current value is less than or equal to 5 A;
- ± 1.5 A when the commanded current value is greater than 5 A but less than or equal to 50 A;
- ± 3 percent of the d.c. electric vehicle supply equipment's maximum current output when the commanded current value is greater than 50 A.

B-6.4 Measuring Current and Voltage

The accuracy of output measurement of system C shall be within the following values:

- Voltage: within ± 10 V; and
- Current: within ± 1.5 percent of reading or within ± 0.5 A, whichever is higher

After a value is measured by the d.c. electric vehicle supply equipment, it shall be send within 200 ms to the electric vehicle or it is remeasured before sending it to the electric vehicle.

The electric vehicle should not solely rely on the voltage and current measurements from the d.c. electric vehicle supply equipment for charge session control.

B-6.5 Overcurrent Protection of d.c. Connection

The d.c. electric vehicle supply equipment shall provide an over-current protection to protect the power supply circuit of the d.c. electric vehicle supply equipment and the vehicle.

If one or both of the following conditions are continuously fulfilled for a duration of 0.5 s, the d.c. electric vehicle supply equipment shall trigger an emergency shutdown within 0.5 s:

- a) current is exceeding 120 percent of the maximum operating current of the station;
- b) during energy transfer the voltage is dropping below 80 percent of the minimum operating voltage of the station.

NOTE — For the protective measures in the vehicle see 6.2 of ISO 17409:2020.

Compliance is tested by **B-9.3.18**.

B-7 SCHEMATICS AND DESCRIPTION

Schematics of system C for d.c. electric vehicle supply equipment is given in Fig. 54, as well definition and description of symbols and terms in Table 53.

B-8 REQUIREMENTS FOR HIGH-LEVEL COMMUNICATION OF d.c. EV SUPPLY EQUIPMENTS USING CHARGING WITH THERMAL MANAGEMENT SYSTEM

For charging with thermal management system, the high-level communication shall be implemented according to IS/ISO 15118-2 to exchange additional information.

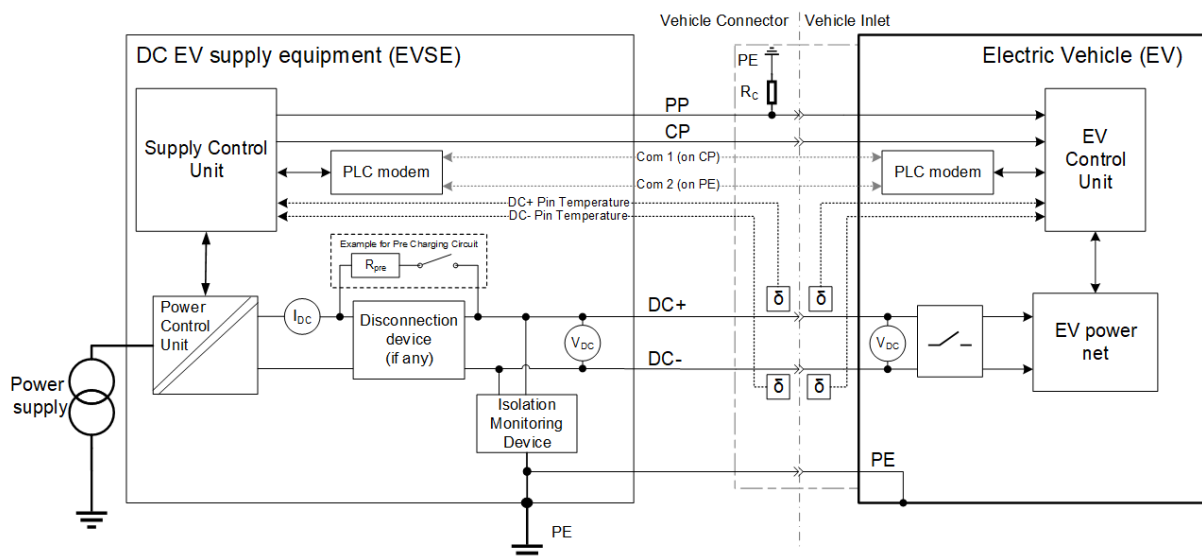
B-9 GENERAL TEST CONDITIONS

B-9.1 Operating Range

B-9.1.1 Definition

Definitions of variables are as follows:

$V_{EVSE\ intended}$	voltage value of testing point
$I_{EVSE\ intended}$	current value of testing point
$V_{EV\ target}$	requested output voltage by the testing system, sent to the d.c. electric vehicle supply equipment via digital communication
$I_{EV\ target}$	requested output current by the testing system, sent to the d.c. electric vehicle supply equipment via digital communication



NOTES

- 1 The supply disconnection device may be substituted by a diode, while the inrush current requirements in **B-6** have to be fulfilled.
2 Diagram shows functional description of interface. Contact assignment of vehicle coupler is done in IS 17017 (Part 2/Sec 3).
3 PP line from vehicle connector to d.c. electric vehicle supply equipment is optional for configuration FF couplers.

FIG. 54 SYSTEM SCHEMATIC EXAMPLE OF SYSTEM C

Table 53 Definition and Description of Symbols / Terms
(Clause B-7)

d.c. EV supply equipment		Electric Vehicle (EV)		Interface Circuit	
Symbols/Terms	Definitions	Symbols/Terms	Definitions	Symbols/Terms	Definitions
V_DC	Voltage Measurement at output of d.c. electric vehicle supply equipment	PLC Modem (Electric vehicle)	electric vehicle Communication interface between PLC and internal electric vehicle communication	PE	Protective conductor
I_DC	Current Measurement (on DC+ or DC- or both)	Electric vehicle Control Unit	Unit for communicating from electric vehicle to the d.c. electric vehicle supply equipment and verifying safety procedure	DC+	d.c. power supply (positive)
Power Conversion Unit	Isolated power stage for converting a.c. supply network into regulated d.c. power for electric vehicle supplying	Electric vehicle Power Net	Subsystem within the electric vehicle related to be supplied with energy from the d.c. electric vehicle supply equipment.	DC-	d.c. power supply (negative)
Disconnection device	Device to connect and disconnect d.c. output of d.c. electric vehicle supply equipment to Power conversion unit a)			Com1	(positive) Line for (PLC) c)
PLC Modem (Supply)	Supply communication interface between PLC and internal supply communication			Com2	(negative) Line for PLC
Supply Control Unit	Unit for control of supply process within d.c. electric vehicle supply equipment and communicating with electric vehicle			PP (Proximity)	General functions acc. to IS 17017 (Part 1) : 2018 with definition of values in Table 42 for configurations FF
R_pre	Resistor for pre charging circuit b)			CP (Control Pilot)	Function acc. to IS 17017 (Part 1) : 2018 Also used for emergency shutdown of d.c. electric vehicle supply equipment by electric vehicle going into state B or interruption of control pilot for CP lost shutdown.
IMD	Insulation Monitoring Device			RC	Proximity-Resistor used for coding of cable current capability in case of a.c. supply acc. values in IS 17017 (Part 1) : 2018.
				CCL (Correct Contact& Latching)	Feedback of correct contact and latching of d.c. vehicle connector
				□□□	Thermal sensing

a The disconnection device may be substituted by a diode.

b Switch and resistor are recommended for implementation of mandatory pre charging function.

c Refer to Table 41 for different connectors.

$V_{EVSE\ output}$	output voltage of the d.c. electric vehicle supply equipment measured by the testing system
$I_{EVSE\ output}$	output current of the d.c. electric vehicle supply equipment measured by the testing system
$V_{EV\ max}$	maximum operating voltage of electric vehicle
$I_{EV\ max}$	maximum operating current of electric vehicle

The values for $V_{EV\ max}$ and $I_{EV\ max}$ shall be set to the maximum corresponding values of the d.c. electric vehicle supply equipment transferred via digital communication

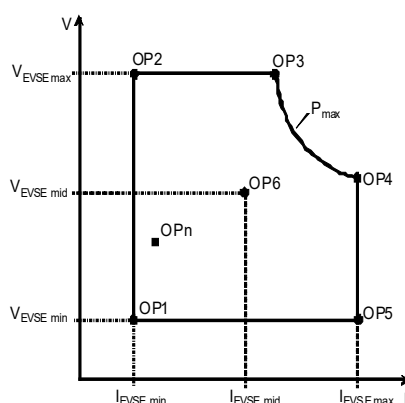
(for example ChargeParameterDiscoveryRes) unless otherwise specified.

If the d.c. electric vehicle supply equipment shows any discontinuous behaviour in its operating range, for example in case of cascaded architecture of power modules, it might be necessary to add additional testing points. In case that the operating area boundaries are reached, additional operating points or shifting of existing points shall be performed in order to fulfil the test requirements.

B-9.2 Test Setup

B-9.2.1 Standard Test Setup

Fig. 56 shows standard test setup.



KEY

$I_{EVSE\ max}$	maximum operating current of electric vehicle supply equipment	OP1	$V_{EVSE\ min}$ and $I_{EVSE\ min}$
$I_{EVSE\ mid}$	$(I_{EVSE\ max} + I_{EVSE\ min}) / 2$	OP2	$V_{EVSE\ max}$ and $I_{EVSE\ min}$
$I_{EVSE\ min}$	minimum operating current of electric vehicle supply equipment	OP3	$V_{EVSE\ max}$ and P_{max}
$V_{EVSE\ max}$	maximum operating voltage of electric vehicle supply equipment	OP4	$I_{EVSE\ max}$ and P_{max}
$V_{EVSE\ mid}$	$(V_{EVSE\ max} + V_{EVSE\ min}) / 2$	OP5	$V_{EVSE\ min}$ and $I_{EVSE\ max}$
$V_{EVSE\ min}$	minimum operating voltage of electric vehicle supply equipment	OP6	$V_{EVSE\ mid}$ and $I_{EVSE\ mid}$
OP	operation point		
OPn	voltage and current depending on test conditions		

NOTE — The defined operating range (OP1-OP5) specifies the possible range for the electric vehicle to request values for voltage and/or current. Within the tolerances, the d.c. EV supply equipment however is allowed to deliver values for current or voltage that are outside of this operating range.

FIG. 55 OPERATING POINTS

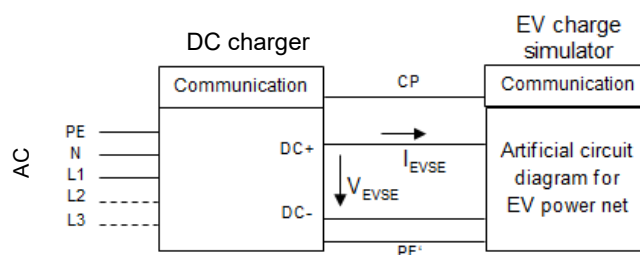


FIG. 56 STANDARD TEST SETUP CIRCUIT DIAGRAM

B-9.3 Test Cases**B-9.3.1 Compatibility Assessment**

The compliance test is shown in Table 54.

B-9.3.2 Wake up of d.c. EV Supply Equipment by EV

The compliance test is shown in Table 55.

B-9.3.3 Details of Pilot Function

The compliance test is shown in Table 56.

B-9.3.4 Protective Conductor Continuity Checking

The compliance test is shown in Table 57.

Table 54 Compliance Test for Compatibility Assessment
(Clause B-9.3.1)

Matching to requirement (chapter)	6.3.1.104 Compatibility assessment 102.5.2 Description of the process before the start of charging (initialization) B-3.2 Normal start up B-3.3 Normal shut down
Short description	
Test, if d.c. electric vehicle supply equipment will not proceed with the charging process in case of: $- V_{EVSE\ min} > V_{EV\ max}$	
Pre-conditions	
for IS/ISO 15118, message “AuthorisationRes” was successfully received by electric vehicle simulator	
Test setup	
Standard test setup, additionally measurement equipment for output voltage $V_{EVSE\ output}$ (continuously measured)	
Action(s)	
for IS/ISO15118-2: send message “ChargeParameterDiscovery.req” containing the following specific value for DC_EVChargeParameterType: Electric vehicle MaximumVoltageLimit = $\max(V_{EVSE\ min} - 10V, 0V)$ proceed with the digital communication according to each standard.	
Expected results	
d.c. electric vehicle supply equipment will not proceed with the next message via digital communication according to each standard. ChargeParameterDiscovery.res contain an EVSEStatusCode = “EVSE_Shutdown” $V_{EVSE\ output} < 60\ V\ d.\ c.$	
Post conditions	
none	

Table 55 Compliance Test for Wake Up of d.c. EV Supply Equipment by EV
(Clause B-9.3.2)

Matching to requirement (chapter)	B-5.2 Wake up of d.c. electric vehicle supply equipment by electric vehicle
Short description	
Reaction on wake up action performed by electric vehicle after d.c. electric vehicle supply equipment fell asleep.	
Pre-conditions	
The d.c. electric vehicle supply equipment has successfully transmitted its following properties to the EV-simulator: $V_{EVSE\ min}, V_{EVSE\ max}, I_{EVSE\ min}, I_{EVSE\ max}, P_{EVSE\ max}$ The charging sequence shall be successfully done until $t=t_8$ according to Fig. 46, including the message “PowerDeliveryReq” (according to IS/ISO 15118), with the following values used during pre-charging: $V_1 = V_{EVSE\ min} - (R_1 + R_2) \times I_{EVSE\ min} \quad \text{if} \quad V_{EVSE\ min} \geq (R_1 + R_2) \times I_{EVSE\ min}$ and: $V_1 = 0\ V \text{ if } V_{EVSE\ min} < (R_1 + R_2) \times I_{EVSE\ min}$ and the parameters “EV _{TargetVoltage} ” in message “PreChargeReq” (according to IS/ISO 15118): $EV_{TargetVoltage} = V_{EV\ target} = V_{EVSE\ min}$	
Test setup	
Standard test setup	
ActAction(s)	

Table 55 (Continued)

In each test step, the EV-simulator shall issue current requests and, if applicable voltage requests. The message “CurrentDemandReq” according to IS/ISO 15118-2 shall contain the following parameters: $EV_{TargetCurrent} = I_{EV\ target}$ $EV_{TargetVoltage} = V_{EV\ target}$ Definition of intended test point (OP5): $I_{EVSE\ intended} = I_{EVSE\ max}$ $V_{EVSE\ intended} = V_{EVSE\ min}$ 1) Set: $V1 = V_{EVSE\ min} - (R1+R2) \times I_{EVSE\ max}$ If $V_{EVSE\ min} - (R1+R2) \times I_{EVSE\ max} \geq 0V$ 2) Send: $I_{EV\ target} = I_{EVSE\ max}$ $V_{EV\ target} = \min(P_{EVSE\ max}/I_{EVSE\ max}; V_{EVSE\ max})$ 3) Wait for T_{wait} (see definition below) in order to reach steady state operation before measuring $T_{wait} = 2\ s + 1.1 \times I_{EVSE\ max} / 20\ A/s$ 4) The test system sends message “PowerDeliveryReq” according to IS/ISO 15118-2 with the parameter “ChargeProgress” set to “Stop” and waits for “PowerDeliveryRes” 5) After receiving “PowerDeliveryRes” the test system sends message “SessionStopReq” according to IS/ISO 15118-2 with the parameter “ChargingSession” set to “Pause” 6) Test system pauses the Data-Link (D-LINK_PAUSE.request()) after receiving SessionStopRes 7) d.c. EV supply equipment changes to sleep mode, which is indicated by a disabled PWM oscillator while CP voltage is set to constant +12 V. 8) Test system performs one B1-C1-B1 toggle according to IS/ISO 15118-3:2015.	
Expected results	
d.c. EV supply equipment signals wake up by enabling the PWM oscillator with a duty cycle of 5 percent.	

Table 56 Compliance Test for Details of Pilot Function

(Clause B-9.3.3)

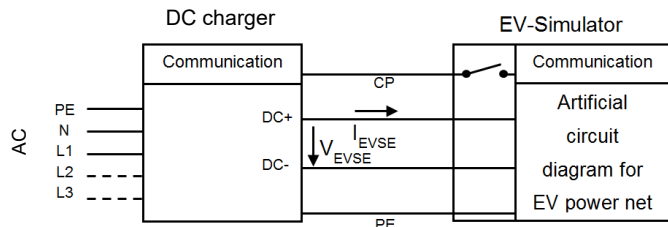
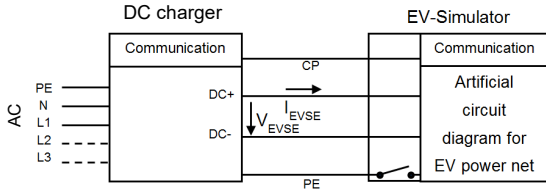
Matching to requirement (chapter)	6.3.1.5 De-energization of the power supply to the EV
Short description	
Start of d.c. charging impossible in case of CP lost	
Pre-conditions	
The electric vehicle supply equipment has successfully transmitted its following properties to the EV-simulator: $V_{EVSE\ min}$, $V_{EVSE\ max}$, $I_{EVSE\ min}$, $I_{EVSE\ max}$, $P_{EVSE\ max}$ The charging sequence shall be successfully done until $t = t1$ according to Fig. 46.	
Test setup	
Standard test setup, additional relay for opening CP 	
Action(s)	
Interrupt control pilot	
Expected results	
The d.c. electric vehicle supply equipment shall stop the ongoing charging session.	

Table 57 Compliance Test for Protective Conductor Continuity Checking
(Clause B-9.3.4)

Matching to requirement (chapter)	6.3.1.2 Continuous continuity checking of the protective conductor 6.3.1.112 and 6.3.1.113 Voltage limitation between d.c. output and protective conductor
Short description	
Emergency shutdown in case of loss of protective conductor continuity. This test case applies to d.c. electric vehicle supply equipments with a maximum output voltage ≥ 60 V.	
Pre-conditions	
The d.c. electric vehicle supply equipment has successfully transmitted its following properties to the EV-simulator: $V_{EVSE\ min}, V_{EVSE\ max}, I_{EVSE\ min}, I_{EVSE\ max}, P_{EVSE\ max}$ The charging sequence shall be successfully done until $t=t_8$ according to Fig. 46, including the message “PowerDeliveryReq” (according to IS/ISO 15118), with the following values used during pre-charging: $V_1 = V_{EVSE\ min} - (R_1 + R_2) \times I_{EVSE\ min}$ if $V_{EVSE\ min} \geq (R_1 + R_2) \times I_{EVSE\ min}$ and: $V_1 = 0$ V if $V_{EVSE\ min} < (R_1 + R_2) \times I_{EVSE\ min}$ and the parameters “EVTargetVoltage” in message “PreChargeReq” (according to IS/ISO 15118): $EV_{TargetVoltage} = V_{EV\ target} = V_{EVSE\ min}$	
Test setup	
Standard test setup with additional relay for interruption of protective conductor continuity.	
	
The maximum emergency shutdown time $t_{shutdown}$ is determined by the following equation: $t_{shutdown} = t_{trigger} + t_{perform}$ with: $t_{trigger} = 10$ ms for isolated systems $t_{perform} = 30$ ms	
Action(s)	
In each test step, the EV-simulator shall issue current requests and, if applicable voltage requests. The message “CurrentDemandReq” according to IS/ISO 15118 shall contain the following parameters: $EV_{TargetCurrent} = I_{EV\ target}$ $EV_{TargetVoltage} = V_{EV\ target}$ Definition of intended test point (OP5): $I_{EVSE\ intended} = I_{EVSE\ max}$ $V_{EVSE\ intended} = V_{EVSE\ min}$ 1) Set: $V_1 = V_{EVSE\ min} - (R_1 + R_2) \times I_{EVSE\ max}$ If $V_{EVSE\ min} - (R_1 + R_2) \times I_{EVSE\ max} \geq 0$ V 2) Send: $I_{EV\ target} = I_{EVSE\ max}$ $V_{EV\ target} = \min(P_{EVSE\ max} / I_{EVSE\ max}; V_{EVSE\ max})$ 3) Wait for T_{wait} (see definition below) in order to reach steady state operation before measuring $T_{wait} = 2$ s + $1.1 \times I_{EVSE\ max} / 20$ A/s 4) Interrupt protective conductor inside EV-simulator	
Expected results	
The electric vehicle supply equipment shall turn off the CP oscillator. After $t_{shutdown} = 40$ ms the output current of the d.c. electric vehicle supply equipment ($I_{EVSE\ output}$) shall be < 5 A. 1.01 s after the occurrence of the fault the output voltage of the d.c. electric vehicle supply equipment ($V_{EVSE\ output}$) shall be < 60 V.	

B-9.3.5 Rated Outputs and Maximum Output Power

The compliance test is shown in Fig. 57 and Table 58.

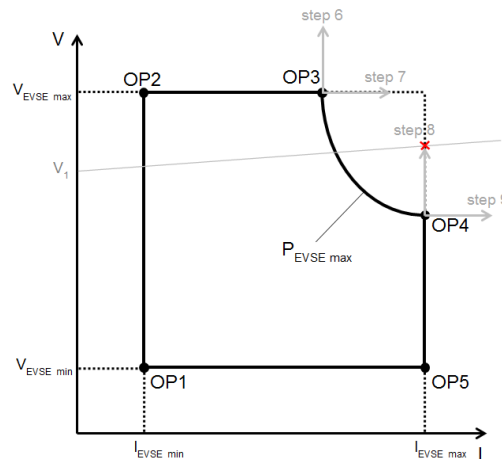


FIG. 57 TEST POINT GRID

Table 58 Compliance Test for Rated Outputs and Maximum Output Power
(Clause B-9.3.5)

Matching to requirement (chapter)	101.2.1 Operating ranges for output voltage, output current and output power
Short description	
1. Test if the d.c. electric vehicle supply equipment does not exceed its maximum rated power, even if the maximum power request by the electric vehicle is beyond the rated maximum power of the d.c. electric vehicle supply equipment. 2. Test if the d.c. electric vehicle supply equipment is able to deliver d.c. power in the voltage range $[V_{\min}, V_{\max}]$ and the regulated current range $[I_{\min}, I_{\max}]$ within the limit of its maximum rated power $[P_{\max}]$ at the ambient temperature -5°C to 55°C below 1 000 m above sea level.	
Pre-conditions	
The electric vehicle supply equipment has successfully transmitted its following properties to the EV-simulator: $V_{\text{EVSE min}}, V_{\text{EVSE max}}, I_{\text{EVSE min}}, I_{\text{EVSE max}}, P_{\text{EVSE max}}$ The charging sequence shall be successfully done until $t=t_8$ according to Fig. 46, including the message “PowerDeliveryReq” (according to IS/ISO 15118), with the following values used during pre-charging: $V_1 = V_{\text{EVSE min}} - (R_1 + R_2) \times I_{\text{EVSE min}}$ if $V_{\text{EVSE min}} \geq (R_1 + R_2) \times I_{\text{EVSE min}}$ and: $V_1 = 0 \text{ V}$ if $V_{\text{EVSE min}} < (R_1 + R_2) \times I_{\text{EVSE min}}$ and the parameters “EVTargetVoltage” in message “PreChargeReq” (according to IS/ISO 15118): $\text{EV}_{\text{TargetVoltage}} = V_{\text{EV target}} = V_{\text{EVSE min}}$	
Test setup	
Standard test setup, additionally: To avoid dynamical influence by unknown inductances in the electric vehicle supply equipment, the test shall be executed in a stationary set point. Measure in this stationary phase for a duration of 3 s with a measurement rate of 100 ms or better. Stationary ambient temperature (as specified at 101.2.1): Case 1: Minimum ambient temperature as specified by manufacturer Case 2: -5°C Case 4: $+22^{\circ}\text{C}$ Case 3: $+55^{\circ}\text{C}$ Case 4: Maximum ambient temperature as specified by manufacturer	
Action(s)	

Table 58 (Continued)

This test case shall be executed in single steps as indicated below.

In each test step, the EV-simulator shall issue current/voltage requests (that is “CurrentDemandReq” in case of PLC communication according to IS/ISO 15118) with the parameter as given in the list below according to the specifications of :

$$EV_{\text{targetCurrent}} = I_{EV \text{ target}} ;$$

$$EV_{\text{targetVoltage}} = V_{EV \text{ target}} ;$$

The evaluation of the expected results shall be done in steady state operation.

The order of sequence of test points can be optimized for the used load. Delay times between the test points can be used. *For example*, for cooling down the load.

For each step the following description uses indices m and n.

m: The consecutive index is used to identify the value of the intended current respectively target current.

n: This consecutive index is used to identify the value of the voltage V1, respectively intended voltage or target voltage.

Main actions to be performed for all test points:

1. set V1 to the values as defined below.
2. For each test point TP request $I_{EV \text{ target}}$ and $V_{EV \text{ target}}$ with the values as defined below.
3. Wait T_{delay} (see definition below) in order to reach steady state operation before measuring.
4. Measure electric vehicle supply equipment output current $I_{EVSE \text{ output m,n}}$ and output voltage $V_{EVSE \text{ output m,n}}$.

Calculations:

Determine active output power

$$P_{EVSE \text{ output m,n}} = I_{EVSE \text{ output m,n}} \times V_{EVSE \text{ output m,n}}$$

Definitions:

$$T_{\text{delay}} = 2 \text{ s for current steps of } < 20 \text{ A}$$

$$T_{\text{delay}} = 2 \text{ s} + 1.1 \times (|I_{EVSE \text{ intended m,n}} - \text{previous } I_{EVSE \text{ output}}|) / 20 \text{ A/s for current steps of } \geq 20 \text{ A}$$

Target values requested to set test point $TP_{m,n}$:

Steps 1-9 shall be tested at each case listed above:

Step 1: (see OP5 in Fig. 55)

$$I_{EV \text{ target}} = I_{EVSE \text{ max}}$$

$$V_{EV \text{ target}} = V_{EVSE \text{ min}}$$

Step 2: (see OP4 in Fig. 55)

$$I_{EV \text{ target}} = I_{EVSE \text{ max}}$$

$$V_{EV \text{ target}} = P_{EVSE \text{ max}} / I_{EVSE \text{ max}}$$

Step 3: (see OP3 in Fig. 55)

$$I_{EV \text{ target}} = P_{EVSE \text{ max}} / V_{EVSE \text{ max}}$$

$$V_{EV \text{ target}} = V_{EVSE \text{ max}}$$

Step 4: (see OP2 in Fig. 55)

$$I_{EV \text{ target}} = I_{EVSE \text{ min}}$$

$$V_{EV \text{ target}} = V_{EVSE \text{ max}}$$

Step 5: (see OP1 in Fig. 55)

$$I_{EV \text{ target}} = I_{EVSE \text{ min}}$$

$$V_{EV \text{ target}} = V_{EVSE \text{ min}}$$

Step 6:

$$I_{EV \text{ target}} = P_{EVSE \text{ max}} / V_{EVSE \text{ max}}$$

$$V_{EV \text{ target}} = V_{EVSE \text{ max}}$$

Step 7:

$$I_{EV \text{ target}} = 1.2 (P_{EVSE \text{ max}} / V_{EVSE \text{ max}})$$

$$V_{EV \text{ target}} = V_{EVSE \text{ max}}$$

Step 8:

$$I_{EV \text{ target}} = 1.2 \times I_{EVSE \text{ max}}$$

$$V_{EV \text{ target}} = P_{EVSE \text{ max}} / I_{EVSE \text{ max}}$$

Table 58 (Concluded)

Step 9: $I_{EV\ target} = I_{EVSE\ max}$ $V_{EV\ target} = 1.2 (P_{EVSE\ max} / V_{EVSE\ max})$ Configuration of the test bench for all steps: $V1 = V_{EV\ target} - (R1 + R2) \times I_{EV\ target}$ With $V1 \geq 0\ V$
Expected results
All Cases, all Steps: All measured current and voltage values shall be positive (> 0) in steady state operation. This test case is passed if each of the following test criteria is fulfilled for all measurements in steady state operation: Step 1: $V_{EVSE\ output} > 0$ Steps 2-4: $V_{EVSE\ output} > 0$ $I_{EVSE\ output} > 0$ Step 5: $V_{EVSE\ output} > 0$ Steps 6-9: The d.c. electric vehicle supply equipment shall not exceed its maximum rated power and shall stop the charging process.

B-9.3.6 Protection against Overvoltage at the Interface

The compliance test is shown in Table 59.

Table 59 Compliance Test for Protection Against Overvoltage At the Battery
(Clause B-9.3.6)

Matching to requirement (chapter)	6.3.1.106 Protection against overvoltage at the interface 6.3.1.114 Shutdown of d.c. electric vehicle supply equipment
Short description	
Emergency shutdown in case of an overvoltage at the interface and disconnection of the d.c. electric vehicle supply equipment's supply.	
Pre-conditions	
The d.c. electric vehicle supply equipment has successfully transmitted its following properties to the EV-simulator: $V_{EVSE\ min}$, $V_{EVSE\ max}$, $I_{EVSE\ min}$, $I_{EVSE\ max}$, $P_{EVSE\ max}$ The charging sequence shall be successfully done until $t=t_8$ according to Fig. 46, including the message "PowerDeliveryReq" (according to IS/ISO 15118), with the following values used during pre-charging: $V1 = V_{EVSE\ min} - (R1 + R2) \times I_{EVSE\ min} \quad \text{if } V_{EVSE\ min} \geq (R1 + R2) \times I_{EVSE\ min}$ and: $V1 = 0\ V \quad \text{if } V_{EVSE\ min} < (R1 + R2) \times I_{EVSE\ min}$ and the parameters "EVTargetVoltage" in message "PreChargeReq" (according to IS/ISO 15118): $EVTargetVoltage = V_{EV\ target} = V_{EVSE\ min}$	
Test setup	
Standard test setup. The maximum error shutdown time $t_{shutdown}$ is defined as follows: $t_{shutdown} = 1.01\ s \ (t_{trigger} = 10\ ms, t_{perform} = 1\ s)$	
Action(s)	
In each test step, the EV-simulator shall issue current requests and, if applicable voltage requests. The message "CurrentDemandReq" according to IS/ISO 15118 shall contain the following parameters:	

Table 59 (Concluded)

$EV_{TargetCurrent} = I_{EV\ target}$ $EV_{TargetVoltage} = V_{EV\ target}$ $EV_{MaximumVoltageLimit} = V_{EV\ max}$ Definition of intended test point: $I_{EVSE\ intended} = I_{EVSE\ min}$ $V_{EVSE\ intended} = V_{EVSE\ min} + (V_{EVSE\ max} - V_{EVSE\ min})/2$ 1) Set: $V1 = V_{EVSE\ min}$ 2) Send: $I_{EV\ target} = I_{EVSE\ min}$ $V_{EV\ target} = V_{EVSE\ min}$ $V_{EV\ max} = V_{EVSE\ min} + (V_{EVSE\ max} - V_{EVSE\ min})/2$ 3) Wait for T_{wait} (see definition below) in order to reach steady state operation $T_{wait} = 2\ s$ 4) Set: $V1 = V_{EV\ max} + 10\ V\ \text{for } 400\ ms$ Editor's NOTE: According to 6.3.1.106 the vehicle shall be able to change the maximum voltage limit during charging process.
Expected results
The electric vehicle supply equipment shall turn off the CP oscillator. After $t_{shutdown} = 1.01\ s$ the output current of the d.c. electric vehicle supply equipment (IEVSE output) shall be $< 5\ A$.

B-9.3.7 Emergency Shutdown in case of Control Pilot Disconnection

The compliance test is shown in Table 60.

Table 60 Compliance Test for Emergency Shutdown In Case of Control Pilot Disconnection
(Clause B-9.3.7)

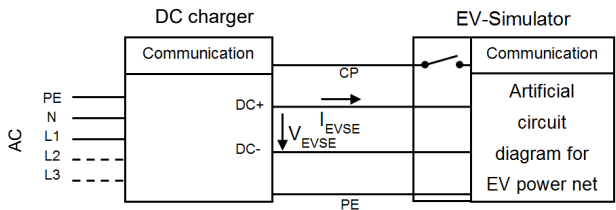
Matching to requirement (chapter)	6.3.1.114 Shutdown of d.c. electric vehicle supply equipment B-4.3 CP lost shutdown
Short description	
Emergency shutdown in case of CP lost.	
Pre-conditions	
The d.c. electric vehicle supply equipment has successfully transmitted its following properties to the EV-simulator: $V_{EVSE\ min}, V_{EVSE\ max}, I_{EVSE\ min}, I_{EVSE\ max}, P_{EVSE\ max}$ The charging sequence shall be successfully done until $t=t_8$ according to Fig. 46, including the message "PowerDeliveryReq" (according to IS/ISO 15118), with the following values used during pre-charging: $V1 = V_{EVSE\ min} - (R1 + R2) \times I_{EVSE\ min} \quad \text{if } V_{EVSE\ min} \geq (R1 + R2) \times I_{EVSE\ min}$ and: $V1 = 0\ V \quad \text{if } V_{EVSE\ min} < (R1 + R2) \times I_{EVSE\ min}$ and the parameters "EVTargetVoltage" in message "PreChargeReq" (according to IS/ISO 15118): $EV_{TargetVoltage} = V_{EV\ target} = V_{EVSE\ min}$	
Test setup	
Standard test setup with additional relay for opening CP: 	

Table 60 (Concluded)

The maximum emergency shutdown time t_{shutdown} is defined as follows: $t_{\text{shutdown}} = t_{\text{trigger}} + t_{\text{perform}} = 40 \text{ ms after control pilot interruption}$ with: $t_{\text{trigger}} = 10 \text{ ms}$ $t_{\text{perform}} = 30 \text{ ms}$ The de-energization time $t_{\text{de-energization}}$ is defined as follows: $t_{\text{de-energization}} = 100 \text{ ms after control pilot interruption}$	
Action(s)	
In each test step, the EV-simulator shall issue current requests and, if applicable voltage requests. The message “CurrentDemandReq” according to IS/ISO 15118 shall contain the following parameters: $\text{EVTargetCurrent} = I_{\text{EV target}}$ $\text{EVTargetVoltage} = V_{\text{EV target}}$ Definition of intended test point (OP5): $I_{\text{EVSE intended}} = I_{\text{EVSE max}}$ $V_{\text{EVSE intended}} = V_{\text{EVSE min}}$ 1) Set: $V1 = V_{\text{EVSE min}} - (R1+R2) \times I_{\text{EVSE max}}$ If $V_{\text{EVSE min}} - (R1+R2) \times I_{\text{EVSE max}} < 0$, then set $V1 = 0V$ 2) Send: $I_{\text{EV target}} = I_{\text{EVSE max}}$ $V_{\text{EV target}} = \min(P_{\text{EVSE max}} / I_{\text{EVSE max}}; V_{\text{EVSE max}})$ 3) Wait for T_{wait} (see definition below) in order to reach steady state operation before measuring $T_{\text{wait}} = 2 \text{ s} + 1.1 \times I_{\text{EVSE max}} / 20 \text{ A/s}$ 4) Interrupt control pilot inside EV-simulator 5) Initiate charging process after emergency shutdown has been performed	
Expected results	
After $t_{\text{shutdown}} = 40 \text{ ms}$ the output current of the d.c. electric vehicle supply equipment ($I_{\text{EVSE output}}$) shall be $< 5 \text{ A}$ 1.01 s after the occurrence of the fault the output voltage of the d.c. electric vehicle supply equipment ($V_{\text{EVSE output}}$) shall be $< 60 \text{ V}$. After $t_{\text{de-energization}} = 100 \text{ ms}$ the output voltage of the d.c. electric vehicle supply equipment ($V_{\text{EVSE output}}$) shall be $< 60 \text{ V}$ The d.c. electric vehicle supply equipment does not go into ready mode until the station is serviced. (The message “ChargeParameterDiscoveryRes” according to IS/ISO 15118 shall contain $\text{DC\_EVSEStatusCode} \neq \text{EVSE\_Ready}$).	

B-9.3.8 Load Dump

The compliance test is shown in Table 61.

Table 61 Compliance Test for Load Dump
(Clause B-9.3.8)

Matching to requirement (chapter)	101.2.7 Load dump
Short description	
Check if d.c. electric vehicle supply equipment will limit the voltage overshoot to the specified values for each system in case of load dump.	
Pre-conditions	
The electric vehicle supply equipment has successfully transmitted its following properties to the EV-simulator: $V_{\text{EVSE min}}, V_{\text{EVSE max}}, I_{\text{EVSE min}}, I_{\text{EVSE max}}, P_{\text{EVSE max}}$ The charging sequence shall be successfully done until $t=t8$ according to Fig. 46, including the message “PowerDeliveryReq” (according to IS/ISO 15118), with the following values used during pre-charging:	

Table 61 (Concluded)

$V1 = V_{EVSE\ min} - (R1 + R2) \times I_{EVSE\ min} \text{ if } V_{EVSE\ min} \geq (R1 + R2) \times I_{EVSE\ min}$ and: $V1 = 0\ V \text{ if } V_{EVSE\ min} < (R1 + R2) \times I_{EVSE\ min}$ and the parameters “EVTargetVoltage” in message “PreChargeReq” (according to IS/ISO 15118): $EVTargetVoltage = V_{EV\ target} = V_{EVSE\ min}$
Test setup
Standard test setup Switch S3 closed
Action(s)
The message “CurrentDemandReq” according to IS/ISO 15118 shall contain the following parameters: $EVTargetCurrent = I_{EV\ target}$ $EVTargetVoltage = V_{EV\ target}$ $EVMaximumVoltageLimit = V_{EV\ max}$ Definition of intended test point: $I_{EVSE\ intended} = I_{EVSE\ min}$ $V_{EVSE\ intended} = 1.1 \times V_{EVSE\ min}$ 1) Set: $V1 = 1.1 \times V_{EVSE\ min} - (R1+R2) \times I_{EVSE\ max}$ if $1.1 \times V_{EVSE\ min} - (R1+R2) \times I_{EVSE\ max} \geq 0\ V$ 2) Send: $I_{EV\ target} = I_{EVSE\ min}$ $V_{EV\ target} = 1.1 \times V_{EVSE\ min}$ $V_{EV\ max} = 1.2 \times V_{EVSE\ min}$ 3) Wait for T_{wait} (see definition below) in order to reach steady state operation $T_{wait} = 2\ s + 1.1 \times I_{EVSE\ max} / 20\ A/s$ Main action to be performed: Open S1 (<i>see</i> Fig. 26)
Expected results
$V_{EVSE\ output} \leq 1.1 \times V_{EV\ max}$ $dV_{EVSE\ output} / dt \leq 250\ V/ms$

B-9.3.9 Protection Against Uncontrolled Reverse Power Flow From Vehicle

The compliance test is shown in Table 62.

Table 62 Compliance Test for Protection against Uncontrolled Reverse Power Flow from Vehicle
 (Clause B-9.3.9)

Matching Requirement (Chapter)	101.1 Protection against uncontrolled reverse power flow from vehicle
Short description	
Test if electric vehicle supply equipment will prevent any reverse power flow from the vehicle.	
Pre-conditions	
The charging sequence shall be successfully done until $t=t8$ according to Fig. 46, including the message “PowerDeliveryReq” (according to IS/ISO 15118), with the following values used during pre-charging: $V1 = V_{EVSE\ min} - (R1 + R2) \times I_{EVSE\ min} \text{ if } V_{EVSE\ min} \geq (R1 + R2) \times I_{EVSE\ min}$ and: $V1 = 0\ V \text{ if } V_{EVSE\ min} < (R1 + R2) \times I_{EVSE\ min}$ and the parameters “EVTargetVoltage” in message “PreChargeReq” (according to IS/ISO 15118):	

Table 62 (Concluded)

$EV_{TargetVoltage} = V_{EV\ target} = V_{EVSE\ min}$ The message “CurrentDemandReq” according to IS/ISO 15118 shall contain the following parameters: $EV_{TargetCurrent} = I_{EV\ target}$ $EV_{TargetVoltage} = V_{EV\ target}$ $I_{EV\ target} = I_{EVSE\ min}$ $V_{EV\ target} = V_{EVSE\ min} + (V_{EVSE\ max} - V_{EVSE\ min})/2$ Setting of the test bench: $V1 = V_{EV\ target} - (R1 + R2) \times I_{EV\ target}$
Test setup
Standard test setup
Action(s)
The EV-simulator shall issue the identical values for current and, if applicable voltage requests as send in the pre-conditions. 1. Set $V1 = V_{EV\ target} + 10\ V$ 2. Wait 250 ms to start current measurement for $I_{EVSE\ output}$
Expected results
$I_{EVSE\ output} \geq 0$ for a duration of 3 s

B-9.3.10 Limiting Inrush Current by d.c. EV Supply Equipment to 2A

The compliance test is shown in Table 63.

**Table 63 Compliance Test for Limiting the Inrush Current By d.c.
Electric Vehicle Supply Equipment To 2A**
(Clause B-9.3.10)

Matching Requirement (Chapter)	B-6.2 Turn on inrush current
Short description	
Check if the d.c. electric vehicle supply equipment limits the inrush current to max. 2A in case of closing the electric vehicle disconnecting device after pre-charge sequence.	
Pre-conditions	
The electric vehicle supply equipment has successfully transmitted its following properties to the EV-simulator: $V_{EVSE\ min}$, $V_{EVSE\ max}$, $I_{EVSE\ min}$, $I_{EVSE\ max}$, $P_{EVSE\ max}$ The message “PrechargeReq” according to IS/ISO 15118 shall contain the following parameter: $EV_{TargetVoltage} = V_{EV\ target}$ with: $V_{EV\ target} = V_{EVSE\ max}$ Precharge sequence shall be successfully done until: $V_{EVSE\ output} = [0.95 \times V_{EV\ target}, V_{EV\ target}]$	
Test setup	
Standard test setup	
Action(s)	
1. Set $V1 = V_{EVSE\ output} - 20V$ 2. Close S0 3. Measure $I_{EVSE\ output}$ 1ms after closing S0 until first CurrentDemandRes message.	
Expected results	
$0A \leq I_{EVSE\ output} \leq 2\ A$	

B-9.3.11 Output Current Regulation in CCC Including Static Deviation and Ripple

The compliance test is shown in Fig. 58 and Table 64.

Fig. 58 shows a simplified example of the test point grid with indices $m = 0 \dots 4$ and $n = 0 \dots 6$ in order to visualize the principal testing sequence of this test case. However, the test point grid that shall actually be used

for this test case shall cover indices $m = 0 \dots 20$ and $n = 0 \dots 20$, with some additional restrictions as described below.

The correlation between current and voltage is given by the following formula:

$$V_{EVSE, m, n} = V1_n + (R1 + R2) \times I_{EVSE, m, n}$$

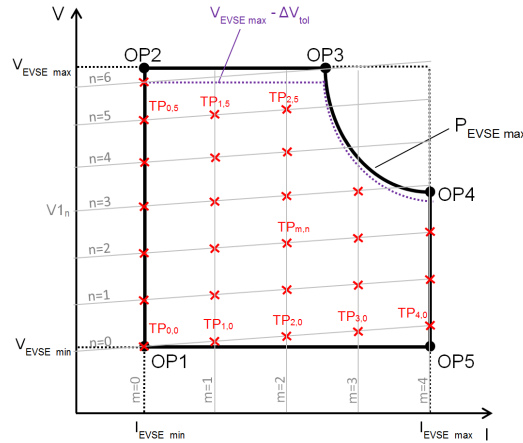


FIG. 58 TEST POINT GRID FOR OUTPUT CURRENT REGULATION IN CCC INCLUDING STATIC DEVIATION AND RIPPLE

**Table 64 Compliance Test for Output Current Regulation In CCC
(Including Static Deviation and Ripple) and Measurement Accuracy**

(Clause B-9.3.11)

Matching to requirement (chapter)	101.2.1 Rated outputs and maximum output power 101.2.2.1 Output current regulation in CCC 101.2.5 Periodic and random deviation (current ripple) 6.3.1.102 Measuring current and voltage
Short description	Check if the current regulation fulfils the requirements for static, periodic and random deviation. Check accuracy of current measurement.
Pre-conditions	The electric vehicle supply equipment has successfully transmitted its following properties to the EV-simulator: $V_{EVSE\ min}, V_{EVSE\ max}, I_{EVSE\ min}, I_{EVSE\ max}, P_{EVSE\ max}$ The charging sequence shall be successfully done including the message "PowerDeliveryReq" (according to IS/ISO 15118), with the following values used during pre-charging: $V1 = V_{EVSE\ min} - (R1 + R2) \times I_{EVSE\ min}$ if $V_{EVSE\ min} \geq (R1 + R2) \times I_{EVSE\ min}$ and: $V1 = 0\ V$ if $V_{EVSE\ min} < (R1 + R2) \times I_{EVSE\ min}$ and the parameter "EVTargetVoltage" in message "PreChargeReq" (according to IS/ISO 15118): $EVTargetVoltage = V_{EV\ target} = V_{EVSE\ min}$
Test setup	Standard test setup, additionally: Measure in the stationary phase for a duration of 3 seconds. All measurements during this time shall be used for calculation and for expected results.
Action(s)	In the steps of this test case, certain properties of the EVSE are tested at specific test points in the operating range of the EVSE. The indices m and n are used as follows to refer to a specific test point $TP_{m, n}$: m : This consecutive index is used to identify the value of the intended current, or the target current, respectively. n : This consecutive index is used to identify the value of the voltage $V1$, or – together with index m – the intended voltage, respectively.

Table 64 (Concluded)

The message “CurrentDemandReq” according to IS/ISO 15118 shall contain the following parameters:

$$EV_{\text{TargetCurrent}} = I_{EV \text{ target } m, n}$$

$$EV_{\text{TargetVoltage}} = V_{EV \text{ target } m, n}$$

Definition of test point grid $TP_{m, n}$:

Indices range:

$$m = 0 \dots 20, n = 0 \dots 20$$

with:

$$\Delta V_{\text{tol}} = 0.02 \times V_{EVSE \text{ max}} + 5 \text{ V} \quad \text{derived from 101.2.2.2 and 101.2.6}$$

NOTE: ΔV_{tol} is needed in order to achieve current regulation (CCC)

Test point $TP_{m, n} = (I_{EVSE \text{ intended } m, n} | V_{EVSE \text{ intended } m, n})$ with:

$$I_{EVSE \text{ intended } m, n} = I_{EVSE \text{ min}} + m/20 \times (I_{EVSE \text{ max}} - I_{EVSE \text{ min}}) \quad (1)$$

$$V_{EVSE \text{ intended } m, n} = V_{EVSE \text{ min}} + n/20 \times (V_{EVSE \text{ max}} - \Delta V_{\text{tol}} - V_{EVSE \text{ min}}) + (R1 + R2) \times (I_{EVSE \text{ intended } m, n} - I_{EVSE \text{ min}}) \quad (2)$$

$$V_{EVSE \text{ intended } m, n} + \Delta V_{\text{tol}} \leq V_{EVSE \text{ max}} \quad (3)$$

$$(V_{EVSE \text{ intended } m, n} + \Delta V_{\text{tol}}) \times I_{EVSE \text{ intended } m, n} \leq P_{EVSE \text{ max}} \quad (4)$$

All equations (1) to (4), where applicable, shall be fulfilled for each $TP_{m, n}$. If any of the equations (1) to (4) is not fulfilled for certain values of m and/or n, $(I_{EVSE \text{ intended } m, n} | V_{EVSE \text{ intended } m, n})$ is *not* a test point $TP_{m, n}$.

Target values requested to set test point $TP_{m, n}$:

$$I_{EV \text{ target } m, n} = I_{EVSE \text{ intended } m, n} \quad (5)$$

$$V_{EV \text{ target } m, n} = \min(P_{EVSE \text{ max}} / I_{EV \text{ target } m, n}; V_{EVSE \text{ max}}) \quad (6)$$

Configuration of the test bench for test point $TP_{m, n}$:

$$V1_n = V_{EVSE \text{ min}} + n/20 \times (V_{EVSE \text{ max}} - \Delta V_{\text{tol}} - V_{EVSE \text{ min}}) - (R1 + R2) \times I_{EVSE \text{ min}} \quad (7)$$

with:

$$V1_n \geq 0 \text{ V} \quad (8)$$

If (7) results in $V1_n < 0 \text{ V}$, $V1_n$ shall be set to $V1_n = 0 \text{ V}$.

Calculations done continuously during for the measurement duration of each $TP_{m, n}$ (3 s):

Determine active output power:

$$P_{EVSE \text{ output } m, n} = I_{EVSE \text{ output } m, n} \times V_{EVSE \text{ output } m, n} \quad (9)$$

Determine the absolute static current deviation value of the 0 Hz component (that is pure d.c.) of the output current $I_{EVSE \text{ output } m, n}$:

$$I_{\text{dev abs } m, n} = |I_{EVSE \text{ output } m, n} - I_{EV \text{ target } m, n}| \quad \text{for } I_{EV \text{ target } m, n} < 50 \text{ A} \quad (10)$$

Determine the relative static current deviation value of the 0 Hz component (that is pure d.c.) of the output current $I_{EVSE \text{ output } m, n}$:

$$I_{\text{dev rel } m, n} = |I_{EVSE \text{ output } m, n} - I_{EV \text{ target } m, n}| / I_{EV \text{ target } m, n} \quad \text{for } I_{EV \text{ target } m, n} \geq 50 \text{ A} \quad (11)$$

Determine the maximum amplitude value ($I_{\text{rip low } m, n}$) of all current ripple components of the output current $I_{EVSE \text{ output } m, n}$ in the frequency band above 0 Hz and below 10 kHz

Determine the maximum amplitude value ($I_{\text{rip mid } m, n}$) of all current ripple components of the output current $I_{EVSE \text{ output } m, n}$ in the frequency band above 0 Hz and below 5 kHz

Determine the maximum amplitude value ($I_{\text{rip high } m, n}$) of all current ripple components of the output current $I_{EVSE \text{ output } m, n}$ in the frequency band above 0 Hz and below 150 kHz

Determine the absolute static current deviation value of the value measured by the d.c. electric vehicle supply equipment and transmitted via digital communication from the 0 Hz component (that is pure d.c.) of the output current $I_{EVSE \text{ output } m, n}$:

$$I_{\text{dev measure } m, n} = |I_{EVSE \text{ measure } m, n} - I_{EVSE \text{ output } m, n}| \quad (11a)$$

Determine necessary wait time:

for $m = 0$:

$$T_{\text{wait}} = I_{EVSE \text{ min}} / (20 \text{ A/s}) \quad \text{for } I_{EVSE \text{ min}} \geq 20 \text{ A}$$

$$T_{\text{wait}} = 1 \text{ s} \quad \text{for } I_{EVSE \text{ min}} < 20 \text{ A}$$

for $m > 0$:

$$T_{\text{wait}} = |I_{EV \text{ target } m, n} - I_{EVSE \text{ output } m-1, n}| / (20 \text{ A/s}) \quad \text{for } |I_{EV \text{ target } m, n} - I_{EVSE \text{ output } m-1, n}| \geq 20 \text{ A}$$

$$T_{\text{wait}} = 1 \text{ s} \quad \text{for } |I_{EV \text{ target } m, n} - I_{EVSE \text{ output } m-1, n}| < 20 \text{ A}$$

Main actions to be performed:

The test points $TP_{m, n}$ shall be covered in sequences generated by two tested loops. The outer loop shall cover the index range of index n ($n = 0 \dots 20$) and therefore step through the different values of the voltage $V1$. The inner loop shall cover the index range of index m ($m = 0 \dots 20$) and therefore step through the different values of the intended output current (“current-step-sequence”), taking into account the maximum output power of the d.c. electric vehicle supply equipment.

All equations (1) to (4), where applicable, shall be fulfilled for each $TP_{m, n}$, so for some values of n, the index range of the inner loop might not reach all values of m.

In each current-step-sequence, a series of current values (indicated by index m) for a constant value of $V1$, that is for a fixed value of index n, shall be used for the test.

Within each current-step-sequence (for example $m = 0 \dots 20, n = 0, TP_{0 \dots m \text{ max}, 0}$), only the value of the current demand $I_{EV \text{ target } m, n}$ shall be altered for the individual test points, the value of $V1$ shall remain constant (for example for $n = 0$: $V1_0$ to be used for $TP_{0 \dots 20, 0}$). After each current-step-sequence (that is after testing $TP_{20, n}$), the current demand $I_{EV \text{ target } m, n}$ shall be set to 0 A and communicated to the electric vehicle supply equipment in order to stop the energy flow from the electric vehicle supply equipment. Then, index n shall be incremented by 1, that is $V1$ shall be adjusted to the voltage value of the following sequence (for example for $n = 1$: $V1_1$ to be used for $TP_{0 \dots 20, 1}$) and then the following current-step-sequence shall be started (for example $m = 0 \dots 20, n = 1, TP_{0 \dots 20, 1}$).

Table 64 (Concluded)

The following pseudo code structure shows the actions to be taken during the execution of this test case. Please refer to the equations above for information on the individual values.

```

Set n = 0
Start outer loop
Set  $V1_n$ 
Set m = 0
Start inner loop (current-step-sequences)
Determine necessary wait time  $T_{wait}$ 
Request target values to set test point  $TP_{m,n}$  by sending the message "CurrentDemandReq" according to IS/ISO 15118
Wait for  $T_{wait}$ 
Measure  $I_{EVSE\ output\ m,n}$  and  $V_{EVSE\ output\ m,n}$ 
Get  $I_{EVSE\ measure\ m,n}$  from digital communication
Perform calculations to be done for each test point  $TP_{m,n}$ 
Check if expected results are achieved
Increment m by 1
If  $m \leq 20$  and equations (1) to (5) are fulfilled, jump to beginning of inner loop
Request target value  $I_{EV\ target} = 0\ A$  by sending the message "CurrentDemandReq"
Wait for  $1.1 \times I_{EVSE\ output\ m-1,n} / (100\ A/s)$ 
Increment n by 1
If  $n \leq 20$ , jump to beginning of outer loop
End Test

```

NOTE — The slew rate of 100 A/s was chosen based on "101.2.4 Descending rate of charging current". The factor 1.1 was chosen to provide an additional 10 percent margin.

Expected results

This test case is passed if each of the following test criteria is fulfilled for each tested $TP_{m,n}$:

$$V_{EVSE\ output\ m,n} > 0 \quad (12)$$

$$I_{EVSE\ output\ m,n} > 0 \quad (13)$$

$$P_{EVSE\ output\ m,n} \leq P_{EVSE\ max} \quad (14)$$

$$I_{rip\ low\ m,n} \leq 0.75\ A \quad (15)$$

$$I_{rip\ mid\ m,n} \leq 3\ A \quad (16)$$

$$I_{rip\ high\ m,n} \leq 4.5\ A \quad (17)$$

$$I_{dev\ measure\ m,n} \leq \max(0.5\ A \mid 0.015 \times I_{EVSE\ output\ m,n}) \quad (17a)$$

$$\text{For } I_{EVSE\ target\ m,n} \leq 50\ A \quad (18)$$

$$\text{All calculated values for } I_{dev\ abs\ m,n} \leq 2.5\ A \quad (18)$$

$$\text{For } I_{EVSE\ target\ m,n} \geq 50\ A \quad (19)$$

$$I_{dev\ rel\ m,n} \leq 0.05 \quad (19)$$

B-9.3.12 Output Voltage Regulation in CVC During Pre-Charging

The compliance test is shown in Fig. 59 and Table 65.

Fig. 59 shows a simplified example of the test point

grid with indices $n = 0 \dots 6$ in order to visualize the principal testing sequence of this test case. However, the test point sequence that shall actually be used for this test case shall cover indices $n = 0 \dots 20$, with some additional restrictions as described below.

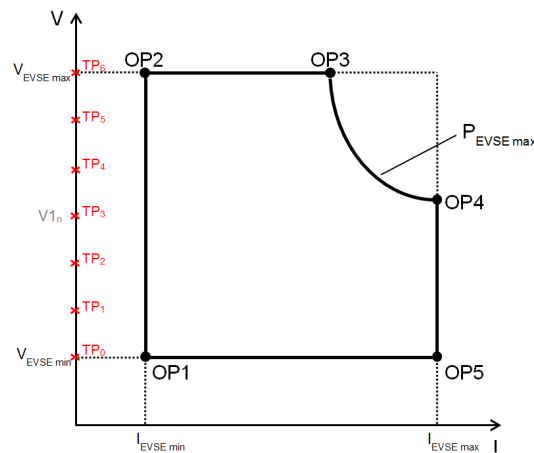


FIG. 59 TEST POINT GRID FOR OUTPUT VOLTAGE REGULATION IN CVC DURING PRE-CHARGING

**Table 65 Compliance Test for Output Voltage Regulation In CVC During Pre-Charging
And Measurement Accuracy**
(Clause B-9.3.12)

Matching to requirement (chapter)	101.2.2.2 Output voltage regulation in CVC 101.2.6 Periodic and random deviation 6.3.1.102 Measuring current and voltage
Short description	
Check if static voltage regulation during pre-charging fulfills the tolerance requirements. Check accuracy of voltage measurement.	
Pre-conditions	
The electric vehicle supply equipment has successfully transmitted its following properties to the electric vehicle: $V_{EVSE\ min}, V_{EVSE\ max}, I_{EVSE\ min}, I_{EVSE\ max}, P_{EVSE\ max}$ The charging sequence shall be successfully done until $t=t_6$ according to Fig. 46.	
Test setup	
Standard test setup, but S0 is open, additionally: Measure in the stationary phase for a duration of 3 seconds	
Action(s)	
In each test step, the EV-simulator shall issue current / voltage requests. The message “CurrentDemandReq” according to IS/ISO 15118 shall contain the following parameters: $EVtargetCurrent = I_{EV\ target}$ $EVtargetVoltage = V_{EV\ target}$ For each step the following description uses index n. n: This consecutive index is used to identify the value of the voltage V1, respectively intended voltage or target voltage. Definition of test point grid TP_n : $n = 0 \dots 20$ $TP_n = (I_{EVSE\ intended} V_{EVSE\ intended\ m,\ n})$ with $I_{EVSE\ intended} = 0\ A$ (1) $V_{EVSE\ intended,\ n} = V_{EVSE\ min} + n/20 \times (V_{EVSE\ max} - V_{EVSE\ min})$ (2) Calculations: Determine active output power $P_{EVSE\ output\ n} = I_{EVSE\ output\ n} \times V_{EVSE\ output\ n}$ (3) Determine the absolute static deviation $V_{dev\ abs\ n} = V_{EVSE\ output\ n} - V_{EV\ target\ n}$ (4) Determine the relative static voltage deviation $V_{dev\ rel\ n} = V_{EVSE\ output\ n} - V_{EV\ target\ n} / V_{EV\ target\ n}$ (5) Determine the peak voltage ripple $V_{rip\ n}$ up to a frequency of 150 kHz (see Figure 15) $V_{rip\ n} = \text{peak value of } (V_{EVSE\ output\ rip\ n} - V_{EVSE\ output\ n})$ (6) Determine the absolute static voltage deviation value of the value measured by the d.c. electric vehicle supply equipment and transmitted via digital communication from the 0 Hz component (that is pure d.c.) of the output voltage $V_{EVSE\ output\ n}$: $V_{dev\ measure\ n} = V_{EVSE\ measure\ n} - V_{EVSE\ output\ n}$ (6a) Definitions: $T_{wait} = 7\ s$ NOTE — According to B-2 the charge control communication shall comply with IS/ISO 15118. which specifies a pre-charge timeout of 7 s. Main actions to be performed: For each test point TP_n request $I_{EV\ target\ n}$ and $V_{EV\ target\ n}$ with the values as defined below. Wait for T_{wait} (see definition above) in order to reach steady state operation before measuring. Measure electric vehicle supply equipment output current $I_{EVSE\ output\ n}$ and output voltage $V_{EVSE\ output\ m,\ n}$.	

Table 65 (Concluded)

Get $V_{EVSE\ measure\ m,n}$ from digital communication	
Target values requested to set test point TP_n :	
$V_{EV\ target\ n} = V_{EVSE\ intended\ n}$	(7)
$I_{EV\ target\ m,n} = 0\ A$	(8)
Configuration of the EV-simulator for test point TP_n :	
$V1_n = V_{EVSE\ min} + n/20 \times (V_{EVSE\ max} - \Delta V_{tol} - V_{EVSE\ min}) - (R1 + R2) \times I_{EVSE\ min}$	(9)
with:	
$V1_n \geq 0\ V$	(10)
NOTE — If (9) results in $V1_n < 0\ V$, $V1_n$ shall be set to $V1_n = 0\ V$.	
Expected results	
This test case is passed if each of the following test criteria is fulfilled for each TP_n :	
$V_{EVSE\ output\ n} > 0$	(11)
$I_{EVSE\ output\ n} = 0$	(12)
$ V_{EVSE\ output\ n} - V_{EV\ target\ n} / V_{EV\ target\ n} \leq 0.05$	(13)
$ V_{EVSE\ output\ n} - V_{EV\ target\ n} \leq 0.02 \times V_{EVSE\ max}$	(14)
$V_{rip\ n} \leq 5\ V$	(15)
$V_{dev\ measure\ n} \leq 10\ V$	(16)

B-9.3.13 Control Delay of Charging Current in CCC

The compliance test is shown in Fig. 60 and Table 66.

Fig. 60 shows a simplified example of the test point grid with indices $m = 0 \dots 4$ and $n = 0 \dots 6$ in order to visualize the principal testing sequence of this test case. However, the test point grid that shall actually be used

for this test case shall cover indices $m = 0 \dots 20$ and $n = 0 \dots 20$, with some additional restrictions as described below.

The correlation between current and voltage is given by the following formula:

$$V_{EVSE, m, n} = V1_n + (R1 + R2) \times I_{EVSE, m, n}$$

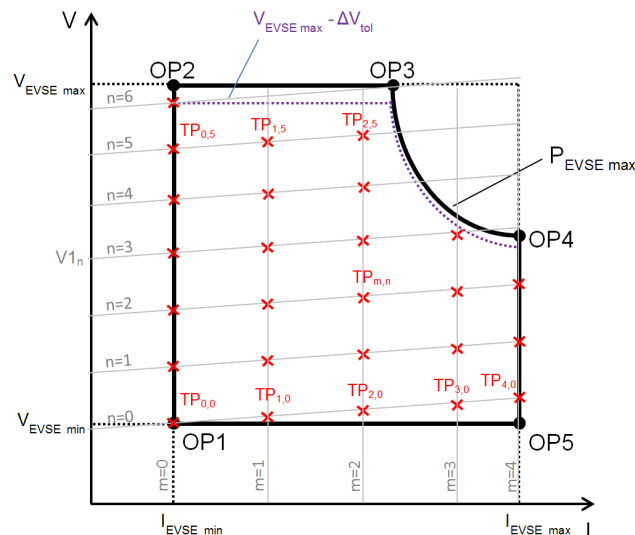
**FIG. 60 TEST POINT GRID FOR CONTROL DELAY OF CHARGING CURRENT IN CCC**

Table 66 Compliance Test for Control Delay of Charging Current In CCC
(Clause B-9.3.13)

Matching to requirement (chapter)	101.2.3 Control delay of charging current in CCC
Short description	
Check the control delay of the charging current in CCC for the largest possible change of the requested current.	
Pre-conditions	
The electric vehicle supply equipment has successfully transmitted its following properties to the EV-simulator: $V_{EVSE\ min}, V_{EVSE\ max}, I_{EVSE\ min}, I_{EVSE\ max}, P_{EVSE\ max}$ The charging sequence shall be successfully done including the message “PowerDeliveryReq” (according to IS/ISO 15118), with the following values used during pre-charging: $V1 = V_{EVSE\ min} - (R1 + R2) \times I_{EVSE\ min} \quad \text{if } V_{EVSE\ min} \geq (R1 + R2) \times I_{EVSE\ min}$ and: $V1 = 0\ V \quad \text{if } V_{EVSE\ min} < (R1 + R2) \times I_{EVSE\ min}$ and the parameters “EVTargetVoltage” in message “PreChargeReq” (according to IS/ISO 15118): $EVTargetVoltage = V_{EV\ target} = V_{EVSE\ min}$	
Test setup	
Standard test setup for d.c. charging EV-simulator, additionally: Determine the 0 Hz (i. e. pure d.c.) component of the EV supply equipment output current $I_{EVSE\ output\ m, n}$ at the point in time defined in the respective test step.	
Action(s)	
In the steps of this test case, certain properties of the electric vehicle supply equipment are tested at specific test points in the operating range of the electric vehicle supply equipment. The indices m and n are used as follows to refer to a specific test point $TP_{m, n}$: m: This consecutive index is used to identify the value of the intended current, or the target current, respectively. n: This consecutive index is used to identify the value of the voltage V1, or – together with index m – the intended voltage, respectively. The message “CurrentDemandReq” according to IS/ISO 15118 shall contain the following parameters: $EVTargetCurrent = I_{EV\ target\ m, n}$ $EVTargetVoltage = V_{EV\ target\ m, n}$ Definition of test point grid $TP_{m, n}$: Indices range: $m = 0 \dots 2, n = 0 \dots 20$ with: $\Delta V_{tol} = 0.02 \times V_{EVSE\ max} + 5\ V \quad \text{derived from 101.2.2.2 and 101.2.6}$ NOTE ΔV_{tol} is needed in order to achieve current regulation (CCC) Test point $TP_{m, n} = (I_{EVSE\ intended\ m, n} \mid V_{EVSE\ intended\ m, n})$ with: $I_{EVSE\ intended\ 0, n} = I_{EVSE\ min} \quad \text{for } m = 0 \tag{1}$ $I_{EVSE\ intended\ 1, n} = \min(I_{EVSE\ max}; I_{EVSE\ Pmax\ n}) \quad \text{for } m = 1 \tag{2}$ $I_{EVSE\ intended\ 2, n} = I_{EVSE\ min} \quad \text{for } m = 2 \tag{3}$ $V_{EVSE\ intended\ m, n} = V_{EVSE\ min} + n/20 \times (V_{EVSE\ max} - \Delta V_{tol} - V_{EVSE\ min}) + (R1 + R2) \times (I_{EVSE\ intended\ m, n} - I_{EVSE\ min}) \tag{4}$ $V_{EVSE\ intended\ m, n} + \Delta V_{tol} \leq V_{EVSE\ max} \tag{5}$ $(V_{EVSE\ intended\ m, n} + \Delta V_{tol}) \times I_{EVSE\ intended\ m, n} \leq P_{EVSE\ max} \tag{6}$ For $m = 1$, $I_{EVSE\ intended\ 1, n} = I_{EVSE\ max}$ shall be used for all $n = 0 \dots n'$ as long as (4), (5), and (6) are fulfilled. For $m = 1$ and $n = n' + 1 \dots 20$, $I_{EVSE\ intended\ 1, n} = I_{EVSE\ Pmax\ n}$ shall be used and $I_{EVSE\ Pmax\ n}$ shall be selected as large as possible such that (4), (5), and (6) are fulfilled, that is in particular: $(V_{EVSE\ intended\ 1, n} + \Delta V_{tol}) \times I_{EVSE\ Pmax\ n} = P_{EVSE\ max} \tag{7}$ All equations (1) to (6), where applicable, shall be fulfilled for each $TP_{m, n}$. If any of the equations (1) to (6) is not fulfilled for certain values of m and/or n, $(I_{EVSE\ intended\ m, n} \mid V_{EVSE\ intended\ m, n})$ is not a test point $TP_{m, n}$. Target values requested to set test point $TP_{m, n}$: $I_{EV\ target\ m, n} = I_{EVSE\ intended\ m, n} \tag{8}$ $V_{EV\ target\ m, n} = \min(P_{EVSE\ max} / I_{EV\ target\ m, n}; V_{EVSE\ max}) \tag{9}$ Configuration of the test bench for test point $TP_{m, n}$: $V1_n = V_{EVSE\ min} + n/20 \times (V_{EVSE\ max} - \Delta V_{tol} - V_{EVSE\ min}) - (R1 + R2) \times I_{EVSE\ min} \tag{10}$ with: $V1_n \geq 0\ V \tag{11}$	

Table 66 (Continued)

If (10) results in $V1_n < 0$ V, $V1_n$ shall be set to $V1_n = 0$ V

Calculations to be done for test point $TP_{m,n}$:

Determine active output power:

$$P_{EVSE\ output\ m,n} = I_{EVSE\ output\ m,n} \times V_{EVSE\ output\ m,n}$$

Determine absolute static current deviation of 0 Hz (i. e. pure d.c.) component:

$$I_{dev\ abs\ m,n} = |I_{EVSE\ output\ m,n} - I_{EV\ target\ m,n}| \quad \text{for } I_{EV\ target\ m,n} < 50\ A$$

Determine relative static current deviation of 0 Hz (i. e. pure d.c.) component:

$$I_{dev\ rel\ m,n} = |I_{EVSE\ output\ m,n} - I_{EV\ target\ m,n}| / I_{EV\ target\ m,n} \quad \text{for } I_{EV\ target\ m,n} \geq 50\ A$$

Determine necessary wait time:

for $m = 0$:

$$T_{wait} = I_{EVSE\ min} / (20\ A/s) \quad \text{for } I_{EVSE\ min} \geq 20\ A$$

$$T_{wait} = 1\ s \quad \text{for } I_{EVSE\ min} < 20\ A$$

for $m > 0$:

$$T_{wait} = |I_{EV\ target\ m,n} - I_{EVSE\ output\ m-1,n}| / (20\ A/s) \quad \text{for } |I_{EV\ target\ m,n} - I_{EVSE\ output\ m-1,n}| \geq 20\ A$$

$$T_{wait} = 1\ s \quad \text{for } |I_{EV\ target\ m,n} - I_{EVSE\ output\ m-1,n}| < 20\ A$$

Main actions to be performed:

In this test case, the electric vehicle supply equipment shall be tested at each test point $TP_{m,n}$ with $m > 0$. The test points $TP_{0,n}$ (that is $m = 0$) are only needed as starting points for the current change. The test points $TP_{m,n}$ shall be covered in sequences generated by two nested loops. The outer loop shall cover the index range of index n ($n = 0 \dots 20$) and therefore step through the different values of the voltage $V1$. The inner loop shall cover the index range of index m ($m = 0..2$) and therefore alternate between the minimum and the maximum value of the intended output current (“current-step-sequence”), taking into account the maximum output power of the electric vehicle supply equipment. (All equations (1) to (6), where applicable, shall be fulfilled for each $TP_{m,n}$.)

In each current-step-sequence, a series of current values (indicated by index m) for a constant value of $V1$, that is for a fixed value of index n , shall be used for the test.

Within each current-step-sequence (for example $m = 0..2, n = 0$, $TP_{0.2,0}$), only the value of the current demand $I_{EV\ target\ m,n}$ shall be altered for the individual test points, the value of $V1$ shall remain constant (for example for $n = 0$: $V1_0$ to be used for $TP_{0.2,0}$). After each current-step-sequence (that is after testing $TP_{2,n}$), the current demand $I_{EV\ target}$ shall be set to 0 A and communicated to the electric vehicle supply equipment in order to stop the energy flow from the electric vehicle supply equipment. Then, index n shall be incremented by 1, that is $V1$ shall be adjusted to the voltage value of the following sequence (for example for $n = 1$: $V1_1$ to be used for $TP_{0.2,1}$) and then the following current-step-sequence shall be started (for example $m = 0..2, n = 1$, $TP_{0.2,1}$).

The following pseudo code structure shows the actions to be taken during the execution of this test case. Please refer to the equations above for information on the individual values.

Set $n = 0$

Start outer loop

 Set $V1_n$

Set $m = 0$

Start inner loop (current-step-sequences)

Determine necessary wait time T_{wait}

Request target values to set test point $TP_{m,n}$ by sending the message “CurrentDemandReq” according to IS/ISO 15118

Wait for T_{wait}

Measure $I_{EVSE\ output\ m,n}$ and $V_{EVSE\ output\ m,n}$

If $m > 0$ Then

 Perform calculations to be done for each test point $TP_{m,n}$

 Check if expected results are achieved

End if

Increment m by 1

If $m \leq 2$ and (5) is fulfilled, jump to beginning of inner loop

Request target value $I_{EV\ target} = 0\ A$ by sending the message “CurrentDemandReq”

Wait for $1.1 \times I_{EVSE\ output\ m-1,n} / (100\ A/s)$

Increment n by 1

If $n \leq 20$, jump to beginning of outer loop

End Test

NOTE — The slew rate of 100 A/s was chosen based on “101.2.4 Descending rate of charging current”. The factor 1.1 was chosen to provide an additional 10 percent margin.

Table 66 (Concluded)

Expected results	
This test case is passed if each of the following test criteria is fulfilled for each $TP_{m,n}$:	
$V_{EVSE\ output\ m,n} > 0$	(10)
$I_{EVSE\ output\ m,n} > 0$	(11)
$P_{EVSE\ output\ m,n} \leq P_{EVSE\ max}$	(12)
For $I_{EV\ target\ m,n} < 50\ A$:	
$I_{dev\ abs\ m,n} \leq 2.5\ A$	(16)
For $I_{EV\ target\ m,n} \geq 50\ A$:	
$I_{dev\ rel\ m,n} \leq 0.05$	(17)

B-9.3.14 Descending Rate of Charging Current

The compliance test is shown in Fig. 61 and Table 67.

Table 67 Compliance Test for Descending Rate of Charging Current
(Clause B-9.3.14)

Matching to requirement (chapter)	101.2.4 Descending rate of charging current
Short description	
Check the descending rate of the charging current in CCC.	
Pre-conditions	
The d.c. electric vehicle supply equipment has successfully transmitted its following properties to the EV-simulator: $V_{EVSE\ min}, V_{EVSE\ max}, I_{EVSE\ min}, I_{EVSE\ max}, P_{EVSE\ max}$ The charging sequence shall be successfully done until $t=t_9$ according to Fig. 46, including the message “PowerDeliveryReq” (according to IS/ISO 15118), with the following values used during pre-charging: $V_1 = V_{EVSE\ min} - (R_1 + R_2) \times I_{EVSE\ min}$ if $V_{EVSE\ min} \geq (R_1 + R_2) \times I_{EVSE\ min}$ and: $V_1 = 0\ V$ if $V_{EVSE\ min} < (R_1 + R_2) \times I_{EVSE\ min}$ and the parameters “EVTargetVoltage” in message “PreChargeReq” (according to IS/ISO 15118): $EVTargetVoltage = V_{EV\ target} = V_{EVSE\ min}$	
Test setup	
Standard test setup	
Action(s)	
In each test step, the EV-simulator shall issue current requests and, if applicable voltage requests. The message “CurrentDemandReq” according to IS/ISO 15118 shall contain the following parameters: $EVTargetCurrent = I_{EV\ target\ m,n}$ $EVTargetVoltage = V_{EV\ target\ m,n}$ 1) Set: $V_{1n} = V_{EV\ target\ m,n} - (R_1 + R_2) \times I_{EVSE\ min}$ if $V_{EV\ target\ m,n} - (R_1 + R_2) \times I_{EVSE\ min} \geq 0$ 2) Send (message CurrentDemandReq according to IS/ISO 15118): : $I_{EV\ target\ m,n} = I_{EVSE\ max}$ $V_{EV\ target\ m,n} = \min(P_{EVSE\ max} / I_{EV\ target\ m,n}; V_{EVSE\ max}) - \Delta V_{tol}$ 3) Wait for T_{wait} (see definition below) in order to reach steady state operation $T_{wait} = 2\ s + 1.1 \times I_{EVSE\ max} / 20\ A/s$ 4) Measure $I_{EVSE\ output}$, store value as “$I_{EVSE\ output,1}$” 5) Send $I_{EV\ target\ m,n} = I_{EVSE\ min}$ and start timer (timestamp t_1) 6) If $I_{EVSE\ output} \leq I_{EVSE\ min} + \Delta I_{tol}$: Measure $I_{EVSE\ output}$, store value as “$I_{EVSE\ output,2}$” and stop timer (timestamp t_2)	

Table 67 (Concluded)

Expected results
This test case is passed if the following test criteria is fulfilled: $((I_{EVSE\ output,1} - I_{EVSE\ output,2})/(100\ A/s)) \geq (t_2 - t_1),$ with $(t_2 - t_1)$ = time elapsed between start and stop of the timer.

Fig. 61 shows a simplified example of the test point grid with indices $m = 0 \dots 2$ and $n = 0 \dots 6$ in order to visualize the principal testing sequence of this test case. However, the test point grid that shall actually be used for this test case shall cover indices $m = 0 \dots 2$ and $n = 0 \dots 20$, with some additional restrictions as described below.

The correlation between current and voltage is given by

the following formula:

$$V_{EVSE\ m, n} = V1_n + (R1 + R2) \times I_{EVSE\ m, n}$$

B-9.3.15 Insulation Checks

B-9.3.15.1 Insulation checks before pre-charge (cable check)

The compliance test is shown in Table 68.

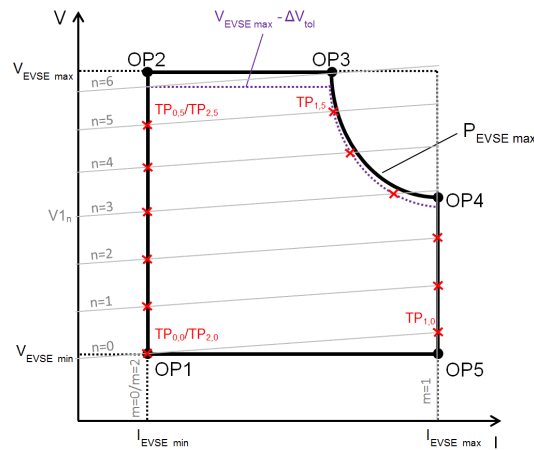


FIG. 61 TEST POINT GRID FOR DESCENDING RATE OF CHARGING CURRENT

Table 68 Compliance Test for Insulation Check To Detect Low Insulation Resistance Before Pre-Charge
(Clause B-9.3.15.1)

Matching to requirement (chapter)	B-4.1.3 Cable check
Short description	
Reaction on low insulation resistance condition	
Pre-conditions	
– Insulation monitoring device according B-4.1 IT (isolated terra) system requirements	
Test setup	
- Symmetrical test: Two test resistors with each $R = 99.5\ k\Omega$ - Asymmetrical test for failure between DC+ and PE: Test resistor $R = 99.5\ k\Omega$ - Asymmetrical test for failure between DC- and PE: Test resistor $R = 99.5\ k\Omega$ NOTE — The requirement requests an insulation resistance of $\geq 100\ k\Omega$. Therefore the injected fault condition should be close to the limit ($\rightarrow 99.5\ k\Omega$).	

Table 68 (Concluded)

Action(s)
This test case shall be executed in single steps as indicated below: - Connect test resistors between DC+ and PE as well as DC- and PE - The charging sequence shall be done until $t = t_4$ (according to Fig. 46) - The EV-simulator shall issue a pre-charge request (that is “PrechargeReq” according to IS/ISO 15118) with $EVTargetVoltage = V_{EV\ target} = V_{EVSE\ min}$. - Connect test resistor between DC+ and PE - The charging sequence shall be done until $t = t_4$ (according to Fig. 46) - The EV-simulator shall issue a pre-charge request (that is “PrechargeReq” according to IS/ISO 15118) with $EVTargetVoltage = V_{EV\ target} = V_{EVSE\ min}$. - Connect test resistor between DC- and PE - The charging sequence shall be done until $t = t_4$ (according to Fig. 46) - The EV-simulator shall issue a pre-charge request (that is “PrechargeReq” according to IS/ISO 15118) with $EVTargetVoltage = V_{EV\ target} = V_{EVSE\ min}$.
Expected results
At $t = t_4$ according to Fig. 46 (reception of CableCheckRes with parameter EVSEProcessing equal to “Finished”): - The EVSE shall have turned off the CP oscillator. $V_{EVSE\ output}$ shall be $\leq 60\ V$ at $t = t_4$ (according to Fig. 46) + 1 s

B-9.3.15.2 Insulation check to detect fault state

The compliance test is shown in Table 69 and Table 70.

Table 69 Compliance Test for Insulation Check To Detect Fault State During Charging
(Clause B-9.3.15.2)

Matching to requirement (chapter)	B-4.1.4 Insulation monitoring during charging
Short description	
Reaction on low insulation resistance condition ($R \leq 100\ \Omega/V$) during current demand phase	
Pre-conditions	
The EVSE has successfully transmitted its following properties to the EV-simulator: $V_{EVSE\ min}$, $V_{EVSE\ max}$, $I_{EVSE\ min}$, $I_{EVSE\ max}$, $P_{EVSE\ max}$ The charging sequence shall be successfully done until $t=t_8$ according to Figure 46, including the message “PowerDeliveryReq” (according to IS/ISO 15118), with the following values used during pre-charging: $V1 = V_{EVSE\ min} - (R1 + R2) \times I_{EVSE\ min} \quad \text{if } V_{EVSE\ min} \geq (R1 + R2) \times I_{EVSE\ min}$ and: $V1 = 0\ V \quad \text{if } V_{EVSE\ min} < (R1 + R2) \times I_{EVSE\ min}$ and the parameters “EVTargetVoltage” in message “PreChargeReq” (according to IS/ISO 15118): $EVTargetVoltage = V_{EV\ target} = V_{EVSE\ min}$ Insulation monitoring device according B-4.1 IT (isolated terra) system requirements	
Test setup	
Standard test setup - Configuration for symmetrical test: Two test resistors with each $R = 99.5\ k\Omega$ - Configuration for 1st asymmetrical test for fault between DC+ and PE: Test resistor $R = 99.5\ k\Omega$ - Configuration for 2nd asymmetrical test for fault between DC- and PE: Test resistor $R = 99.5\ k\Omega$ NOTE — The requirement requests an insulation resistance of $\geq 100\ k\Omega$. Therefore the injected fault condition should be close to the limit ($\rightarrow 99.5\ k\Omega$).	
Action(s)	

Table 69 (Concluded)

The complete sequence of test steps shall be executed with all three resistor configurations as described in the test setup (symmetrical and asymmetrical). The message “CurrentDemandReq” according to IS/ISO 15118 shall contain the following parameters: EVtargetCurrent = $I_{EV\ target}$ EVtargetVoltage = $V_{EV\ target}$ Definition of intended test point (OP5): $I_{EVSE\ intended} = I_{EVSE\ max}$ $V_{EVSE\ intended} = V_{EVSE\ min}$ 1) Set $V1 = V_{EVSE\ min} - (R1+R2) \times I_{EVSEmax}$ If $V_{EVSE\ min} - (R1+R2) \times I_{EVSEmax} \geq 0\ V$ 2) Send $V_{EV\ target} = \min(P_{EVSE\ max} / I_{EVSE\ max}; V_{EVSE\ max})$ $I_{EV\ target} = I_{EVSE\ max}$ 3) Wait for T_{wait} (see definition below) in order to reach steady state operation before measuring. $T_{wait} = 2\ s + 1.1 \times I_{EVSE\ max} / 20\ A/s$ 4) Connect test resistors according to the respective configuration. The maximum error shutdown time $t_{shutdown}$ is defined as follows: $t_{shutdown} = t_{trigger} + t_{perform} = 11\ s$ after occurrence of insulation fault with: $t_{trigger} = 10\ s$ $t_{perform} = 1\ s$	
Expected results	

Table 70 Compliance Test 2 for Self-Test After Fault State
(Clause B-9.3.15.2)

Matching to requirement (chapter)	B-4.1 IT (isolated terra) system requirements
Short description	
Reaction on self test after emergency shutdown due to low insulation resistance condition ($R \leq 100\ \Omega/V$). The insulation fault condition shall be removed before self test starts.	
Pre-conditions	
The electric vehicle supply equipment has successfully transmitted its following properties to the EV-simulator: $V_{EVSE\ min}$, $V_{EVSE\ max}$, $I_{EVSE\ min}$, $I_{EVSE\ max}$, $P_{EVSE\ max}$ The charging sequence shall be successfully done until $t=t8$ according to Figure 46, including the message “PowerDeliveryReq” (according to IS/ISO 15118), with the following values used during pre-charging: $V1 = V_{EVSE\ min} - (R1 + R2) \times I_{EVSE\ min}$ if $V_{EVSE\ min} \geq (R1 + R2) \times I_{EVSE\ min}$ and: $V1 = 0\ V$ if $V_{EVSE\ min} < (R1 + R2) \times I_{EVSE\ min}$ and the parameters “EVTargetVoltage” in message “PreChargeReq” (according to IS/ISO 15118): $EVTargetVoltage = V_{EV\ target} = V_{EVSE\ min}$ Insulation monitoring device according B-4.1 IT (isolated terra) system requirements	
Test setup	
Standard test setup - Configuration for symmetrical test: Two test resistors with each $R = 99\ \Omega/V \times V_{EVSE\ max}$ - Configuration for 1st asymmetrical test for fault between DC+ and PE: Test resistor $R = 99\ \Omega/V \times V_{EVSE\ max}$ - Configuration for 2nd asymmetrical test for fault between DC- and PE: Test resistor $R = 99\ \Omega/V \times V_{EVSE\ max}$ NOTE — The requirement requests an insulation resistance of $\geq 100\ \Omega/V$. Therefore the injected fault condition should be close to the limit ($\rightarrow 99\ \Omega/V$).	

Table 70 (Concluded)

Action(s)
The complete sequence of test steps shall be executed with all three resistor configurations as described in the test setup (symmetrical and asymmetrical). The message “CurrentDemandReq” according to IS/ISO 15118 shall contain the following parameters: EVtargetCurrent = $I_{EV\ target}$ EVtargetVoltage = $V_{EV\ target}$ Definition of intended test point (OP5): $I_{EVSE\ intended} = I_{EVSE\ max}$ $V_{EVSE\ intended} = V_{EVSE\ min}$ 1) Set $V1 = V_{EVSE\ min} - (R1+R2) \times I_{EVSE\ max}$ If $V_{EVSE\ min} - (R1+R2) \times I_{EVSE\ max} \geq 0\ V$ 2) Send $V_{EV\ target} = \min(P_{EVSE\ max} / I_{EVSE\ max}; V_{EVSE\ max})$ $I_{EV\ target} = I_{EVSE\ max}$ 3) Wait for T_{wait} (see definition below) in order to reach steady state operation before measuring. $T_{wait} = 2\ s + 1.1 \times I_{EVSE\ max} / 20\ A/s$ 4) Connect test resistors according to the respective configuration. 5) Wait until EV supply equipment has turned off CP oscillator. 6) Disconnect test resistors. 7) Change CP state to state A, wait for 1 min (to allow the station to perform a self test) and change CP state to state B. 8) Set $V1 = V_{EVSE\ min} - (R1+R2) \times I_{EVSE\ max}$ If $V_{EVSE\ min} - (R1+R2) \times I_{EVSE\ max} < 0\ V$ then set $V1 = 0\ V$ 9) Send $V_{EV\ target} = \min(P_{EVSE\ max} / I_{EVSE\ max}; V_{EVSE\ max})$ $I_{EV\ target} = I_{EVSE\ max}$ 10) Wait for T_{wait} (see definition below) in order to reach steady state operation before measuring. $T_{wait} = 2\ s + 1.1 \times I_{EVSE\ max} / 20\ A/s$
Expected results
The charging sequence shall be successfully done until $t=t9$ according to Fig. 46, that is energy transfer in steady state.

B-9.3.16 Short-Circuit between CP and PE

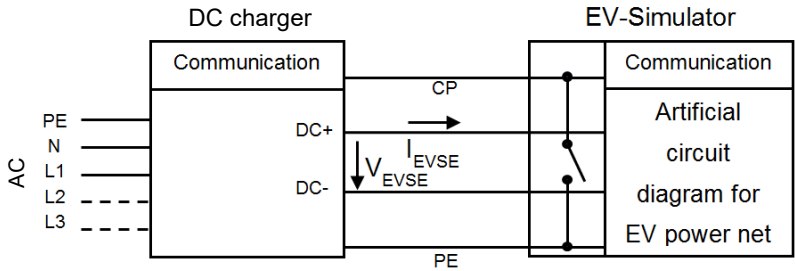
The compliance test is shown in Table 71.

Table 71 Compliance Test for Short-Circuit Between CP and PE

(Clause B-9.3.16)

Matching to requirement (chapter)	Table 2 (state DC-E)
Short description	
Check if d.c. electric vehicle supply equipment will perform an emergency shutdown in case of: Short circuit between CP and PE	
Pre-conditions	
The d.c. electric vehicle supply equipment has successfully transmitted its following properties to the EV-simulator: $V_{EVSE\ min}$, $V_{EVSE\ max}$, $I_{EVSE\ min}$, $I_{EVSE\ max}$, $P_{EVSE\ max}$ The charging sequence shall be successfully done until $t=t9$ according to Fig. 46, including the message “PowerDeliveryReq” (according to IS/ISO 15118), with the following values used during pre-charging: $V1 = V_{EVSE\ min} - (R1 + R2) \times I_{EVSE\ min}$ if $V_{EVSE\ min} \geq (R1 + R2) \times I_{EVSE\ min}$ and: $V1 = 0\ V$ if $V_{EVSE\ min} < (R1 + R2) \times I_{EVSE\ min}$ and the parameters “EVTargetVoltage” in message “PreChargeReq” (according to IS/ISO 15118): EVTargetVoltage = $V_{EV\ target} = V_{EVSE\ min}$	

Table 71 (Concluded)

Test setup	
Standard test setup, additionally relay to short circuit CP and PE	
	
Action(s)	
The EV-simulator shall issue current requests and, if applicable voltage requests. The message “CurrentDemandReq” according to IS/ISO 15118 shall contain the following parameters: EVTargetCurrent = $I_{EV\ target}$ EVTargetVoltage = $V_{EV\ target}$ Definition of intended test point (OP5): $I_{EVSE\ intended} = I_{EVSE\ max}$ $V_{EVSE\ intended} = V_{EVSE\ min}$ 1) Set: $V1 = V_{EVSE\ min} - (R1+R2) \times I_{EVSE\ max}$ If $V_{EVSE\ min} - (R1+R2) \times I_{EVSE\ max} \geq 0\ V$ 2) Send: $I_{EV\ target} = I_{EVSE\ max}$ $V_{EV\ target} = \min(P_{EVSE\ max} / I_{EVSE\ max}; V_{EVSE\ max})$ 3) Wait for T_{wait} (see definition below) in order to reach steady state operation before measuring $T_{wait} = 2\ s + 1.1 \times I_{EVSE\ max} / 20\ A/s$ 4) Close relay between CP and PE	
Expected results	
After 1 s the output current of the d.c. electric vehicle supply equipment ($I_{electric\ vehicleSE\ output}$) shall be $< 5\ A$	

B-9.3.17 Short-Circuit and Overcurrent Protection during Charging

The compliance test is shown in Table 72.

Table 72 Compliance Test for Short-Circuit and Overcurrent Protection

(Clause B-9.3.17)

Matching to requirement (chapter)	13.101 Short-circuit protection of the d.c. connection B-6.6 Overcurrent protection of the d.c. connection
Short description	
Reaction on over-current condition caused by external or internal faults	
Pre-conditions	
The electric vehicle supply equipment has successfully transmitted its following properties to the EV-simulator: $V_{EVSE\ min}$, $V_{EVSE\ max}$, $I_{EVSE\ min}$, $I_{EVSE\ max}$, $P_{EVSE\ max}$ The charging sequence shall be successfully done until $t=t9$ according to Fig. 46, including the message “PowerDeliveryReq” (according to IS/ISO 15118), with the following values used during pre-charging: $V1 = V_{EVSE\ min} - (R1 + R2) \times I_{EVSE\ min}$ if $V_{EVSE\ min} \geq (R1 + R2) \times I_{EVSE\ min}$	

Table 72 (Continued)

and

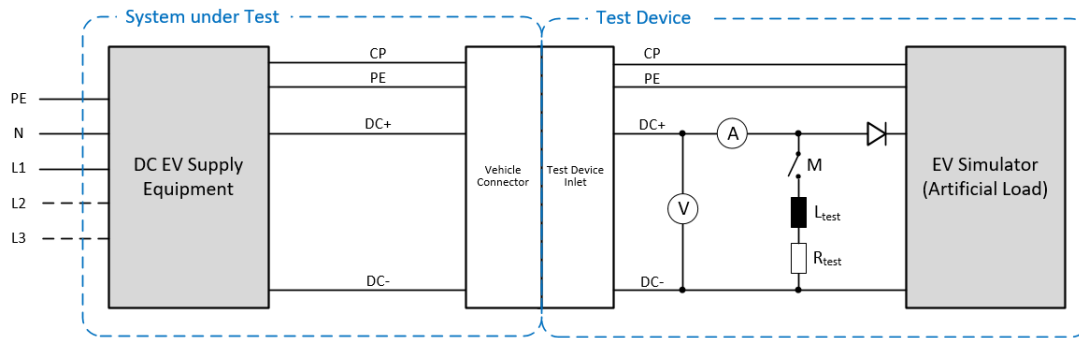
$$V1 = 0 \text{ V if } V_{EVSE \min} < (R1 + R2) \times I_{EVSE \min}$$

and the parameters “EVTargetVoltage” in message “PreChargeReq” (according to IS/ISO 15118)

$$EVTargetVoltage = V_{EV \text{ target}} = V_{EVSE \min}$$

Test setup

The following figure shows a test setup with additional means to create over-current conditions (fault insertion).



The test device shall be configurable with following characteristics:

	Resistance R_{test}	Inductance L_{test}
Configuration 1	$10 \text{ m}\Omega \pm 15 \text{ percent}$	$2 \text{ }\mu\text{H} \leq L_{test} \leq 5 \text{ }\mu\text{H}$
Configuration 2	$100 \text{ m}\Omega \pm 10 \text{ percent}$	$2 \text{ }\mu\text{H} \leq L_{test} \leq 5 \text{ }\mu\text{H}$
Configuration 3	$250 \text{ m}\Omega \pm 10 \text{ percent}$	$2 \text{ }\mu\text{H} \leq L_{test} \leq 5 \text{ }\mu\text{H}$

R_{test} is the resistance of the short-circuit loop of the test device. It shall be measured between the DC+ and DC- contact of the test device inlet at a frequency of $f_{meas} = 1 \text{ kHz}$ (EV-simulator disconnected).

L_{test} is the inductance of the short-circuit loop of the test device. It shall be measured between the DC+ and DC- contact of the test device inlet at a frequency of $f_{meas} = 1 \text{ kHz}$ (EV-simulator disconnected).

The bandwidth of the current and voltage measurement shall be at least 500 kHz.

Contact bouncing of the switching device M shall be avoided by selecting an appropriate switching device.

Action(s)

This test case shall be executed in single steps as indicated below.

In each test step, the EV-simulator shall issue current / voltage requests (that is “CurrentDemandReq” in case of PLC communication according to IS/SO 15118) with the parameter as given in the list below:

$$EVtargetCurrent = I_{EV \text{ target}}$$

$$EVtargetVoltage = V_{EV \text{ target}}$$

Main actions to be performed for all test points:

For each test point TP conduct three single tests using the settings 1, 2 and 3 of the test device as specified in the test setup.

1. Set V1 to the values as defined below.

Table 72 (Concluded)

2. For each test point TP request $I_{EV\ target}$ and $V_{EV\ target}$ with the values as defined below. 3. Wait until steady state operation is reached 4. Close switch M. 5. Measure and log EV supply equipment output current $I_{EVSE\ output}$ and output voltage $V_{EVSE\ output}$ from the point in time when switch M is closed until the point in time when the d.c. EV supply equipment has shut down. 6. Open switch M Calculations: Determine $\sum_n i_n^2 \Delta t_{sample}$ from the point in time when switch M is closed until the point in time when the d.c. electric vehicle supply equipment has shut down. Target values requested to set test points: Step 1: $I_{EV\ target} = I_{EVSE\ max}$ $V_{EV\ target} = P_{EVSE\ max} / I_{EVSE\ max}$ Step 2: $I_{EV\ target} = P_{EVSE\ max} / V_{EVSE\ max}$ $V_{EV\ target} = V_{EVSE\ max}$ Configuration of the test bench for all steps: $V1 = V_{EV\ target} - (R1 + R2) \times I_{EV\ target}$ with $V1 \geq 0\ V$
Expected results
- Short-circuit peak current $\leq 10\ kA$. - $\sum_n i_n^2 \Delta t_{sample} \leq 1\ 000\ 000\ A^2s$ - d.c. output current drops below 5 A within 1.03 s after closing of switch M.

B-9.3.18 Test of Measured Voltage Values During Welding Detection

The compliance test is shown in Table 73.

Table 73 Compliance Test for Measured Voltage Values During Welding Detection

(Clause B-9.3.18)

Matching to requirement (chapter)	Table 46 - Sequence description for normal shutdown (t106--> t107) B-6.5 Measuring current and voltage
Short description	
Check if the voltage values measured by the d.c. electric vehicle supply equipment and transferred via digital communication are correct.	
Pre-conditions	
The d.c. electric vehicle supply equipment has successfully transmitted its following properties to the EV-simulator: $V_{EVSE\ min}$, $V_{EVSE\ max}$, $I_{EVSE\ min}$, $I_{EVSE\ max}$, $P_{EVSE\ max}$ The charging sequence shall be successfully done until $t=t105$ according to Fig. 47, including the message "PowerDeliveryReq" (according to IS/ISO 15118), with the following values used during pre-charging and current demand: $V1 = V_{EVSE\ min} - (R1 + R2) \times I_{EVSE\ min} \quad \text{if } V_{EVSE\ min} \geq (R1 + R2) \times I_{EVSE\ min}$ and: $V1 = 0\ V \quad \text{if } V_{EVSE\ min} < (R1 + R2) \times I_{EVSE\ min}$ and the parameters "EVTargetVoltage" in message "PreChargeReq" and "CurrentDemandReq" (according to IS/ISO 15118): $EVTargetVoltage = V_{EV\ target} = V_{EVSE\ min}$	
Test setup	
Standard test setup	
Action(s)	

Table 73 (Concluded)

1) a. set: $V1 = V_{EVSE\ min}$ b. send: WeldingDetectionReq (according to IS/ISO 15118) c. receive WeldingDetectionRes d. compare received value “EVSEPresentVoltage” with V1 2) a. set: $V1 = V_{EVSE\ max} - (V_{EVSE\ max} - V_{EVSE\ min})/2$ b. send: WeldingDetectionReq (according to IS/ISO 15118) c. receive WeldingDetectionRes d. compare received value “EVSEPresentVoltage” with V1 3) a. set: $V1 = V_{EVSE\ max}$ b. send: WeldingDetectionReq (according to IS/ISO 15118) c. receive WeldingDetectionRes d. compare received value “EVSEPresentVoltage” with V1
Expected results
All received values for “EVSEPresentVoltage” > 0; $IV1 - EVSEPresentVoltageI \leq 10\ V$

B-9.3.19 User Initiated Shutdown

The compliance test is shown in Table 74.

Table 74 Compliance Test for User Initiated Shutdown
(Clause B-9.3.19)

Matching to requirement (chapter)	6.3.1.110 User initiated shutdown
Short description	
Check if d.c. EV supply equipment performs an user initiated shut down.	
Pre-conditions	
The EV supply equipment has successfully transmitted its following properties to the EV-simulator: $V_{EVSE\ min}$, $V_{EVSE\ max}$, $I_{EVSE\ min}$, $I_{EVSE\ max}$, $P_{EVSE\ max}$ The charging sequence shall be successfully done until $t=t_9$ according to Figure 46, including the message “PowerDeliveryReq” (according to IS/ISO 15118), with the following values used during pre-charging: $V1 = V_{EVSE\ min} - (R1 + R2) \times I_{EVSE\ min} \quad \text{if } V_{EVSE\ min} \geq (R1 + R2) \times I_{EVSE\ min}$ and: $V1 = 0\ V \quad \text{if } V_{EVSE\ min} < (R1 + R2) \times I_{EVSE\ min}$ and the parameters “EVTargetVoltage” in message “PreChargeReq” (according to IS/ISO 15118): $EVTargetVoltage = V_{EV\ target} = V_{EVSE\ min}$	
Test setup	
Standard test setup	
Action(s)	
The EV-simulator shall issue current requests and, if applicable voltage requests. The message “CurrentDemandReq” according to IS/ISO 15118 shall contain the following parameters: $EVTargetCurrent = I_{EV\ target}$ $EVTargetVoltage = V_{EV\ target}$	

Table 74 (Concluded)

Definition of intended test point (OP5): $I_{EVSE\ intended} = I_{EVSE\ max}$ $V_{EVSE\ intended} = V_{EVSE\ min}$ 1) Set: $V1 = V_{EVSE\ min} - (R1+R2) \times I_{EVSE\ max}$ If $V_{EVSE\ min} - (R1+R2) \times I_{EVSE\ max} \geq 0\ V$ 2) Send: $I_{EV\ target} = I_{EVSE\ max}$ $V_{EV\ target} = \min(P_{EVSE\ max}/I_{EVSE\ max}; V_{EVSE\ max})$ 3) Wait for T_{wait} (see definition below) in order to reach steady state operation before measuring $T_{wait} = 2\ s + 1.1 \times I_{EVSE\ max} / 20\ A/s$ 4) Activate the customer means to shut down the charging process.
Expected results
Electric vehicle supply equipment sends a "CurrentDemandRes" containing the parameter "EVSEStatusCode = EVSE_Shutdown"

B-9.3.20 Short Circuit Test Before Charging

The compliance test is shown in Table 75.

Table 75 Compliance Test for Short Circuit Test Before Charging
(Clause B-9.3.20)

Matching Requirement (Chapter)	6.3.1.109 Short circuit check before charging
Short description	
Reaction on short circuit between DC+/DC- before charging.	
Pre-conditions	
The electric vehicle supply equipment has successfully transmitted its following properties to the electric vehicle-simulator: $V_{EVSE\ min}, V_{EVSE\ max}, I_{EVSE\ min}, I_{EVSE\ max}, P_{EVSE\ max}$ The charging sequence shall be successfully done until $t=t4$ according to Fig. 46.	
Test setup	
Standard test setup with additional contactor to short circuit DC+/DC-	
Action(s)	
1) Close the contactor between DC+ and DC- 2) The EV-simulator shall perform the Cable Check sequence (that is send "CableCheckReq" according to IS/ISO 15118).	
Expected results	
The electric vehicle supply equipment shall turn off the CP oscillator.	

ANNEX C

(Clause 1 and Annex A)

BI-DIRECTIONAL POWER FLOW CONTROL

C-1 GENERAL

This annex provides basic information on the functional requirements for bi-directional power flow between the d.c. electric vehicle charging/discharging station and the electric vehicle. An example of block diagram of bi-directional power flow system is shown in Fig. 62.

In bi-directional power flow, the electric current flows in the opposite direction to that of the charging process that is power is delivered from the electric vehicle battery to electrical loads and/or the a.c. power grid connected to the supply network.

Although the direction of the current flow is reversed, the system architecture and the hardware interface/connection to the vehicle of the d.c. electric vehicle discharging/charging station are identical to that of the d.c. electric vehicle supply equipment, with some difference in the installed components, the reverse-current protection diode in the d.c. output circuit of the electric vehicle supply equipment, if any, has to be replaced by a pre-charge circuit, otherwise a dedicated d.c./a.c. inverter circuit with its own pre-charge circuit needs to be provided separately in addition to the existing a.c./d.c. converter circuit.

Another important aspect of the bi-directional power flow is the ability of the d.c. electric vehicle charging/discharging station to switch between charging and discharging mode or to remain idle that is stop the current flow, anytime during the charging/discharging session. This can be achieved by the implementation of the two operation modes as described in C-2.

The requirements for grid-connection including bi-directional inverter are provided in IEC 62909-1.

C-2 CHARGING/DISCHARGING MODE

In addition to the requirements in 6.3.1 which defines the electric vehicle charging in mode 4, the following operation modes can be applied to the d.c. electric vehicle charging/discharging station (*see* Fig. 63):

- a) Electric vehicle charging/discharging dynamic mode

In this mode, the electric vehicle and the d.c. electric vehicle charging/discharging station will exchange information about voltage, current and/or power limits before and during the sequence through digital communication.

The d.c. electric vehicle charging/discharging station will deliver current to the electric vehicle or draw current from the electric vehicle within the limits communicated and inform the electric vehicle about the actual voltage and current during the sequence.

The two processes (charging and discharging) can be switched over seamlessly anytime that is without transferring to shutdown sequence.

- b) Electric vehicle charging/discharging scheduled mode

In this mode, the d.c. electric vehicle charging/discharging station will propose charging/discharging schedules to the electric vehicle and the electric vehicle will communicate back a charging/discharging profile to the d.c. electric

IEC 62909-1

Bi-directional Grid Connected Power Converters

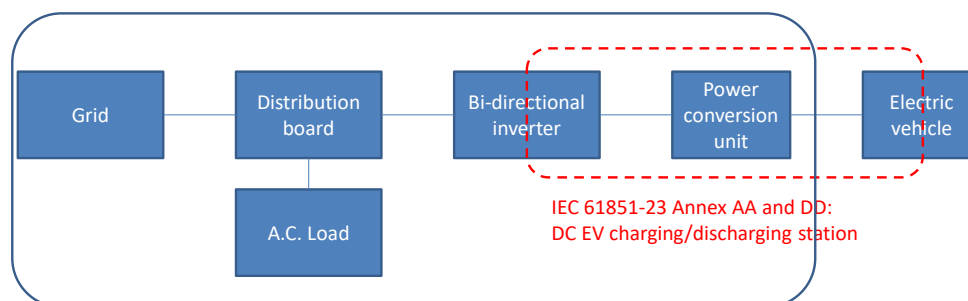


FIG. 62 EXAMPLE OF BLOCK DIAGRAM OF BI-DIRECTIONAL POWER FLOW SYSTEM

vehicle charging/discharging station. This profile will always stay within the voltage, current and/ or power limits communicated by both sides before charging.

During the sequence, the d.c. electric vehicle supply equipment will deliver current to the electric vehicle or draw current from the electric vehicle in respect to the charging/discharging profile communicated and will always inform the electric vehicle about the actual voltage and current during the sequence.

The two processes (charging and discharging) can be switched over seamlessly anytime that is without transferring to shutdown sequence.

c) Electric vehicle discharging mode

This mode can exist independently from charging mode if the d.c. electric vehicle charging/discharging station or equipment is specifically designed for electric vehicle discharging, for example a portable Vehicle-to-Load (V2L) power supply.

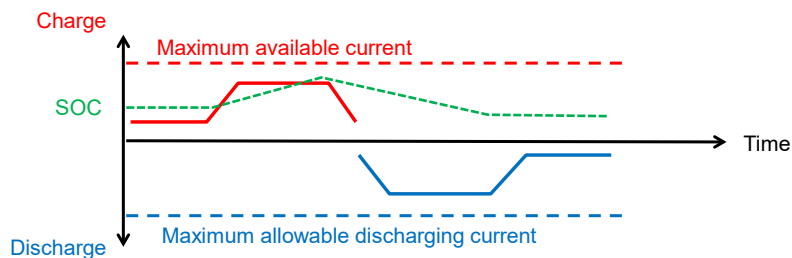
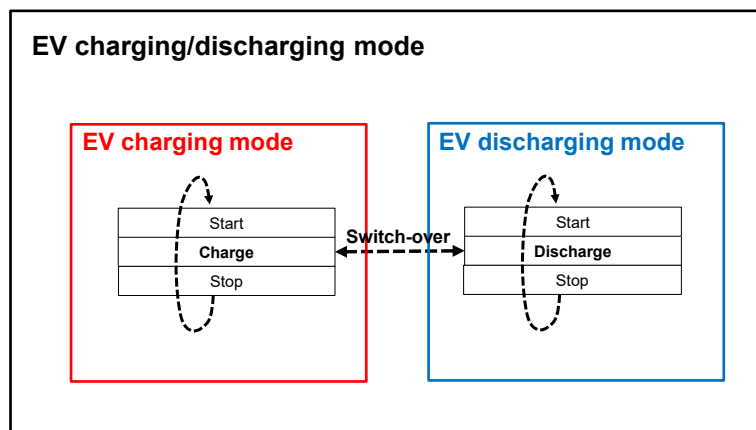


FIG. 63 EV CHARGING AND DISCHARGING MODES

ANNEX D

(Clause 1)

TYPICAL D.C. CHARGING SYSTEM

This annex shows typical diagrams and configuration of d.c. EV charging systems.

Examples of typical isolated system, non-isolated

system, simplified isolated system and d.c. supply network system are shown in Fig. 64, Fig.65, Fig. 66 and Fig. 67.

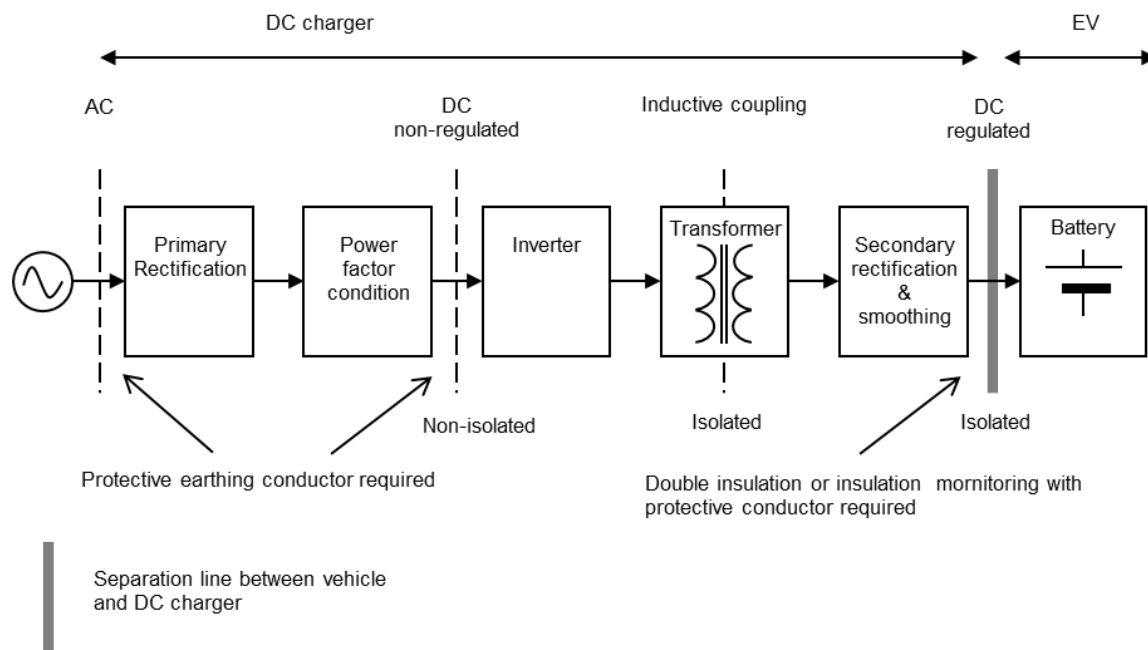


FIG. 64 EXAMPLE OF TYPICAL ISOLATED SYSTEM

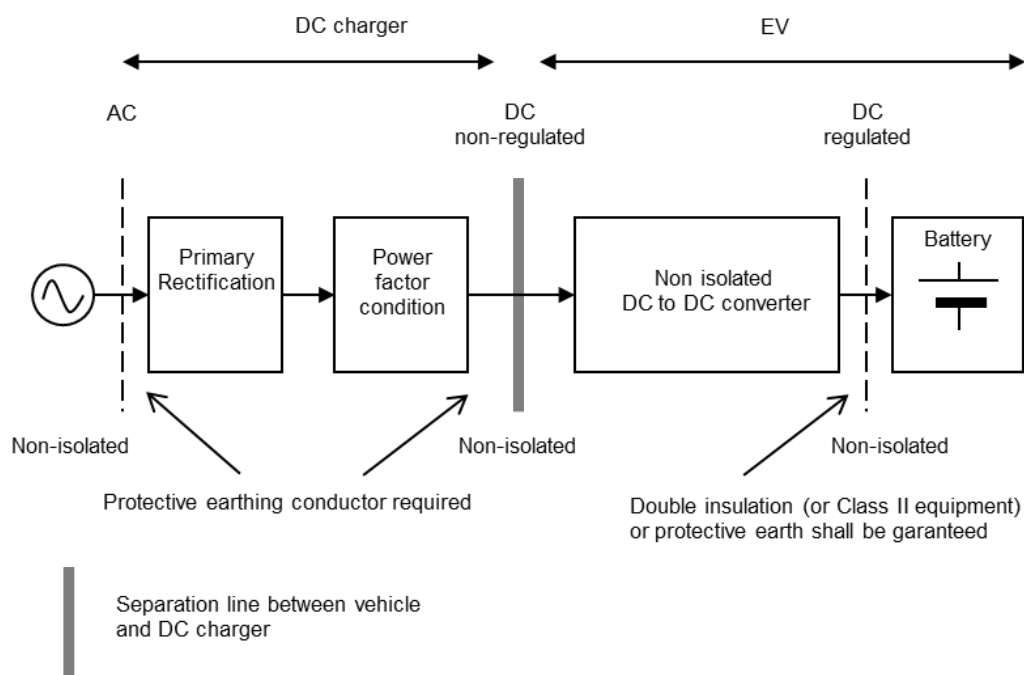


FIG. 65 EXAMPLE OF TYPICAL NON-ISOLATED SYSTEM

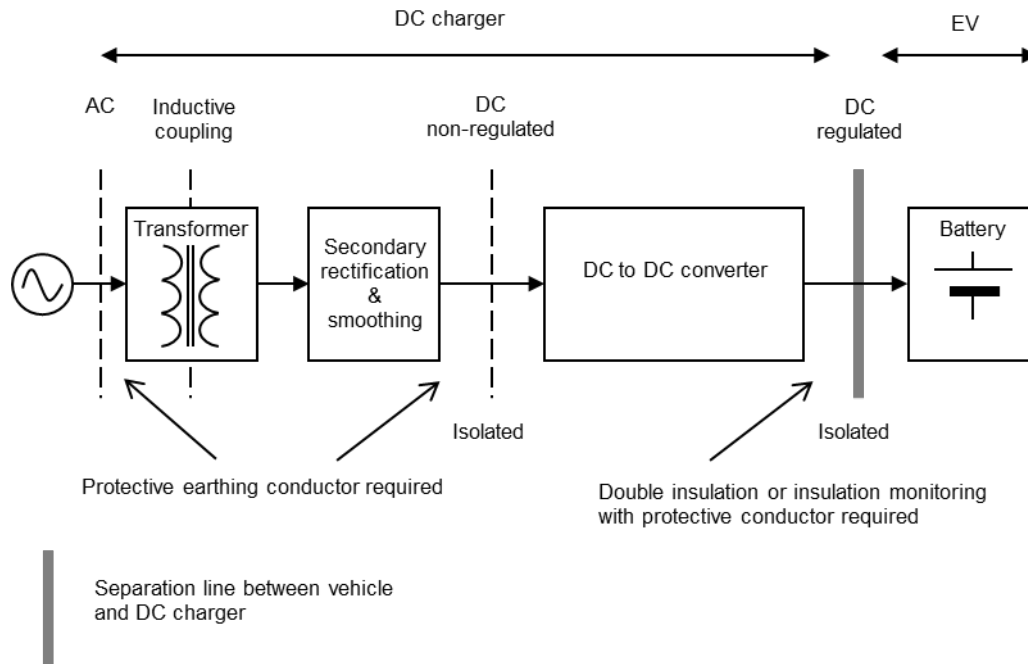


FIG. 66 EXAMPLE OF SIMPLIFIED ISOLATED SYSTEM

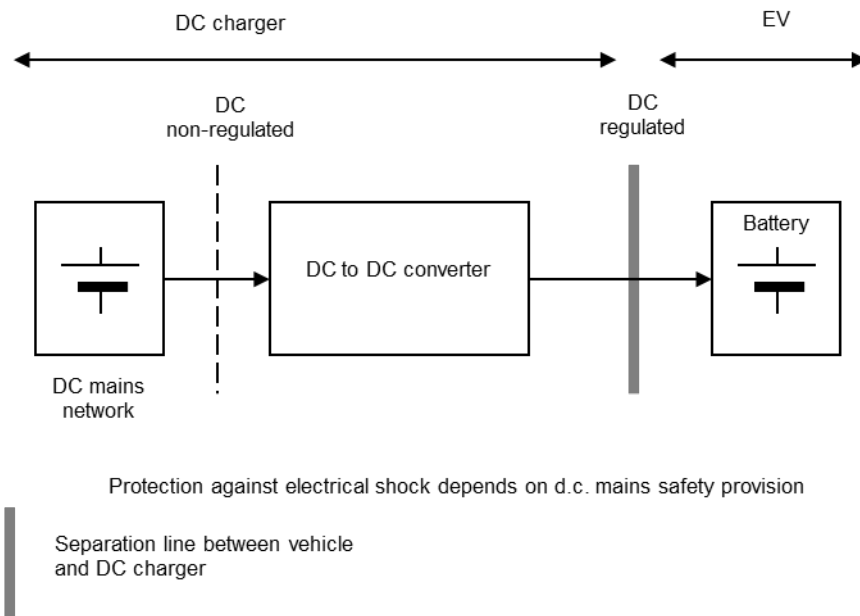
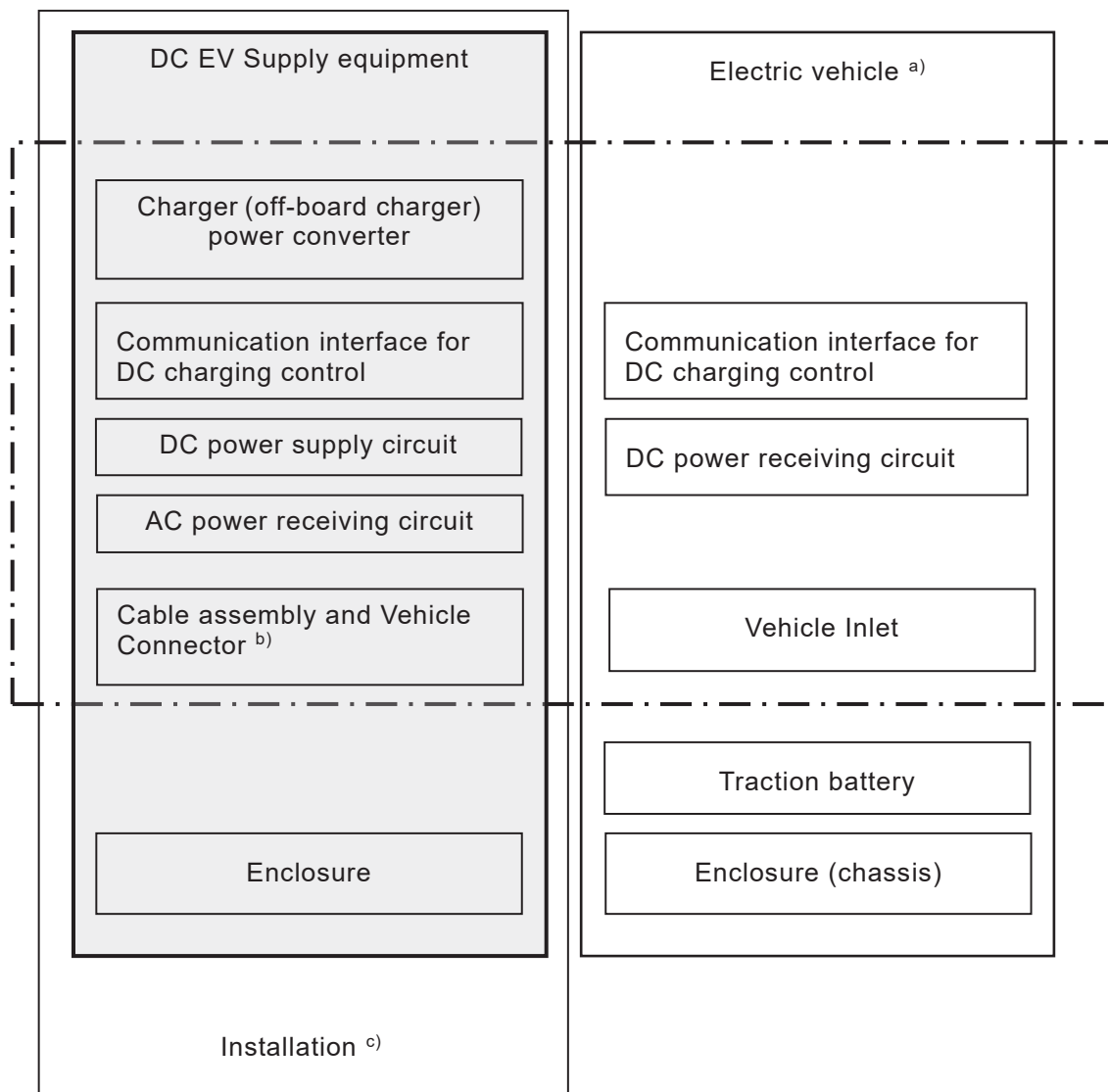


FIG. 67 EXAMPLE OF D.C. SUPPLY NETWORK SYSTEM

Fig. 68 shows the Typical Configuration of d.c. Charging System.



- a) Including information on element of electric vehicle for conductive connection
- b) Detailed requirements for d.c. vehicle couplers are defined in IS 17017 (Part 2/Sec 3) : 2020: —. Requirements for cable assemblies are specified in IS 17017 (Part 2/Sec 1).
- c) Installation (see IEC 60364-7-722) is also applicable for connecting points (standard socket-outlets) intended to supply plug and cable d.c. electric vehicle supply equipment.

FIG. 68 TYPICAL CONFIGURATION OF D.C. CHARGING SYSTEM

ANNEX E

(Clause 101.3)

MULTIOUTLET (A.C./D.C. ISOLATED) D.C. EV SUPPLY EQUIPMENT**E-1 GENERAL**

This annex provides specific requirements for d.c. charging by using a multi-outlet d.c. EV supply equipment. Multi-outlet d.c. electric vehicle supply equipments are d.c. electric vehicle supply equipment with two or more d.c. connecting points. As a part of the d.c. electric vehicle supply equipment, all general requirements for d.c. electric vehicle supply equipments in the body text of this document also apply to the multi-outlet d.c. electric vehicle supply equipment unless otherwise specified in this annex.

E-2 CLASSIFICATION AND USE CASE OF MULTI-OUTLET D.C. EV SUPPLY EQUIPMENT**E-2.1 System Operation**

- a) Multi-outlet d.c. electric vehicle supply equipment with non-simultaneous operation; and
- b) Multi-outlet d.c. electric vehicle supply equipment with simultaneous operation.

E-2.2 Output System

- a) Multi-System A;
- b) Multi-System C ; and
- c) System A and System C.

E-2.3 Configuration

- a) Multi-outlet d.c. electric vehicle supply equipment with single power unit; and
- b) Multi-outlet d.c. electric vehicle supply equipment with multiple (two or more) power units.

The possible combinations for multi-outlet d.c. electric vehicle supply equipments with respect to the classification are shown in Table 76.

Examples of system schematics for the use cases derived from Table 76 are shown in Table 77.

Table 76 The Possible Combinations for Multi-Outlet D.c. Electric Vehicle Supply Equipments
(Clause E-2.3)

Use case							Configuration				Schematic
System operation		Output system					Power unit		galvanic isolation		
Non-simultaneous	Simultaneous	A	B	C	A & B	A & C	Single	multiple	primary	secondary	
x		x					x		x		7
x			x				x				
x				x			x				
x					x		x				
x						x	x				
x		x						x	x		10
x			x					x			
x				x				x			
x					x			x			
x						x		x			
x		x						x	x		9, 12
x			x					x			
x				x				x			
x					x			x			
x						x		x			
x		x						x	x		8, 11
x			x					x			
x				x				x			
x					x			x			
x						x		x			
x	x	x						x		x	3, 6
x	x		x					x			
x	x			x				x			
x	x				x			x			
x	x					x		x			
x		x						x		x	2, 5
x			x					x			
x				x				x			
x					x			x			
x						x		x			
x		x						x		x	1, 4
x			x					x			
x				x				x			
x					x			x			
x						x		x			
x	x	x						x	x	x	13
x	x		x					x			
x	x			x				x			
x	x				x			x			
x	x					x		x			

Table 77 Example of System Schematic for Each Use Case (1 of 4)
(Clause E.2.3)

	Schematic	AC/DC	DC/AC/ AC/DC	Galvanic separation of EVs during simultaneous operation
1	Multi-outlet DC EV supply equipment	single	multiple	not possible
2	Multi-outlet DC EV supply equipment	single	multiple	not possible
3	Multi-outlet DC EV supply equipment	single	multiple	possible
4	Multi-outlet DC EV supply equipment	multiple	multiple	not possible

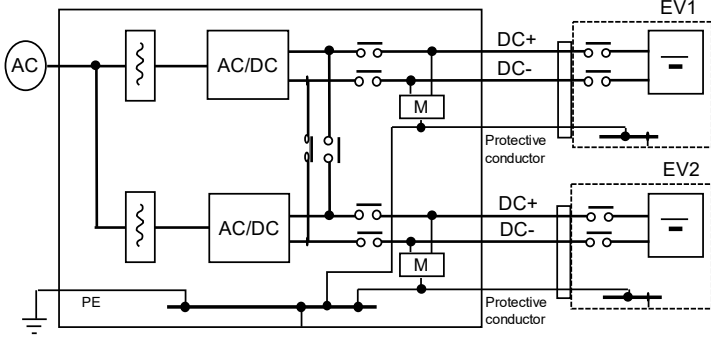
Table 77 (2 of 4)
(Clause E.2.3)

	Schematic	AC/DC	DC/AC/ AC/DC	Galvanic separation of EVs during simultaneous operation
5		multiple	multiple	not possible
6		multiple	multiple	possible
7		single	none	not possible
8		multiple	none	not possible

Table 77 (3 of 4)
(Clause E.2.3)

	Schematic	AC/DC	DC/AC/ AC/DC	Galvanic separation of EVs during simultaneous operation
9		multiple	none	not possible
10		multiple	none	not possible
11		multiple	none	not possible
12		multiple	none	not possible

Table 77 (4 of 4)
(Clause E.2.3)

	Schematic	AC/DC	DC/AC/ AC/DC	Galvanic separation of EVs during simultaneous operation
13		multiple	none	possible

E-3 CONSTRUCTIONAL REQUIREMENTS

E-3.1 Constructional Requirements of d.c. Output System

The d.c. output system shall be equipped with a vehicle connector according to IS 17017(Part 2/Sec 3) and a non-detachable charging cable.

A storage means according to Clause 11.7 shall be provided for all vehicle connectors when not in use. The maximum cable length shall be in accordance with national codes. Clearance and creepage distance of contactors in open state shall be at least basic insulation.

The d.c. output system shall also be equipped with a mechanical disconnection device such as relay/contactors. The device shall be installed in each of the positive and negative power line of the d.c. output circuit of the supply equipment, and be capable of disconnecting the power line of the d.c. electric vehicle supply equipment from the electric vehicle when the system is operating under the maximum rated charging current in simultaneous operation.

E-3.1.1 Constructional Requirements of d.c. Output System According to Annex A

The d.c. output system shall be equipped with a vehicle connector according to IS 17017(Part 2/Sec 3), configuration AA. To ensure proper functionality, the d.c. output system shall be equipped with the necessary hardware for communication and power transmission (for example CAN transceiver, resistors, switches, contactors), according to Annex A, Fig. 28 and

Fig. 29. System A output circuits shall be equipped with contactors on d.c. output.

E-3.1.2 Constructional Requirements of d.c. Output System According to Annex B

The d.c. output system shall be equipped with a vehicle connector according to IS 17017 (Part 2/Sec 3), configuration FF. To ensure proper functionality, the d.c. output system shall be equipped with the necessary hardware for communication and power transmission (for example PWM oscillator, PLC chip, contactors), according to Annex B, Fig. 54 and Fig. A-1 of IS 17017 (Part 1) : 2018.

E-4 D.C. OUTPUT SYSTEM PERFORMANCE

E-4.1 General Performance Requirements

The output systems shall be System A, System C or both System A and C. The d.c. output performance shall comply with the requirements in the body text of this document and with the requirements in the applicable annexes. If two or more outputs can be used simultaneously, mutual interference shall not occur.

E-4.2 Performance of Multi-Outlet d.c. EV Supply Equipments Providing Simultaneous Operation

If the sum of the rated powers of each output circuit exceeds the power rating of the multi-outlet d.c. EV supply equipment, the manufacturer has to specify the possibilities of power distribution in the user's manual (for example priority charging or evenly distributed power on each output circuit).

E-5 SAFETY REQUIREMENTS

E-5.1 General Safety Requirements

The protective conductor in each charging cable of the multi-outlet d.c. electric vehicle supply equipment shall be connected to a common protective earthing conductor.

All output circuits shall be individually equipped with a means of insulation monitoring or d.c. leakage current monitoring, between d.c. power conductor and enclosure of d.c. EV supply equipment, as specified in Annex A or C. Y capacitance at the output terminal of each output circuit shall comply with the requirement in **8.105.1**.

The reaction time of an IMD shall not be influenced during simultaneous operation with an earth leakage current measuring device or other insulation monitoring device.

Circuit components including devices used for isolation shall be rated for the maximum voltage including all specified tolerances of the power output circuits taking into account both normal and single insulation fault.

E-5.2 Short-Circuit Protection

Each connecting point of a multi-outlet d.c. EV charging shall have individual short-circuit protection means. Such means shall comply with the requirement of respective output system given in **13.101**.

E-5.3 Overload Protection

Each connecting point of a multi-outlet d.c. electric vehicle supply equipment shall individually provide overload protection according to **13.2**.

E-5.4 Access to Energized Part Through Unmated Vehicle Connector During Charge

During charge, conductor connected to the accessible unmated vehicle connector shall be isolated by basic or reinforced insulation from the energized d.c. output.

If isolation is achieved by basic insulation, the energy or voltage between a contact of unmated vehicle connector and earth shall be less than or equal to 0.5 mJ or 28 V d.c. continuously in normal operation and after 1 s under a first fault.

Requirement for the insulation barrier specified in **8.105.3** shall be applied to each d.c. output circuit.

E-5.5 Additional Safety Requirements for Multi-Outlet d.c. EV Supply Equipments Providing Simultaneous Operation

If the output systems are equipped with switch components, such as contactors, measures shall be taken to prevent unintended electrical connection of vehicles caused by the failure of switch component. These measures shall prevent the short circuit between batteries of different vehicles. The protection can be achieved by one or combination of the following measures:

- a) Allocation of diode to each output circuit. The diode shall be installed between switch component and output terminal of each outlet;
- b) Allocation of fuse to the circuit equipped with switch component; and
- c) Electrical or mechanical interlock of contactors for preventing simultaneous closure.

If a fault is detected in one output circuit, the multi-outlet d.c. EV supply equipment shall terminate the supply of charging current in all output circuits.

E-5.6 Diagnostic Check of Mechanical Disconnection Device in d.c. Output System

The multi-outlet d.c. electric vehicle supply equipment shall perform the diagnostic check of the mechanical disconnection device installed in the d.c. output system to prevent unexpected power flow from a vehicle to the d.c. electric vehicle supply equipment, or between the two or more vehicles simultaneously connected to the d.c. electric vehicle supply equipment in case the mechanical disconnection device is welded (ON stuck), and to prevent hazardous voltage at the unmated vehicle connector.

As the minimum requirement, the diagnostic shall check the welding (ON stuck) of the mechanical disconnection device. Diagnostic checks of other failures such as OFF stuck and erratic actuation are not mandatory but still recommended.

If the diagnostic check is performed before the start of charging and the ON stuck failure is detected, the charging process shall be terminated and the system shall transfer to shutdown sequence

If the diagnostic check is performed after the completion of a single charging event and the ON stuck failure is detected, the d.c. electric vehicle supply equipment shall prohibit further charging events until the mechanical disconnection device is properly replaced or repaired.

E-5.7 Safety Requirements for Multi-Outlet d.c. Electric Vehicle Supply Equipments with Shared d.c.

Under consideration

ANNEX F

(Clauses 6.3.1.104 and 7.1)

COMMUNICATION AND CHARGING PROCESS BETWEEN d.c. ELECTRIC VEHICLE SUPPLY EQUIPMENT AND ELECTRIC VEHICLE

F-1 DIGITAL COMMUNICATION BETWEEN THE EV SUPPLY EQUIPMENT AND THE ELECTRIC VEHICLE

F-1.1 General

This Annex F provides the general information on the communication and charging process between d.c. electric vehicle supply equipment and electric vehicle.

The requirements of digital communication of charging control between d.c. electric vehicle supply equipment and electric vehicle are defined in IS 17017 (Part 24).

Electric vehicles are equipped with propulsion batteries with different technologies and voltage. Accordingly, the charging process is managed by the vehicle in order to ensure the charging of different types of on-board energy storage systems.

Electric vehicles are equipped with VCCF for charging process management. The d.c. electric vehicle supply equipments have a means allowing the vehicles to control the charging parameters of d.c. electric vehicle supply equipment.

F-1.2 System Configuration

The communication between the d.c. electric vehicle supply equipment and the vehicle can be established via basic communication and high level communications.

Key steps in the charging control process, such as start of charging and normal/emergency shutdown, is managed through the basic communication with signal exchange via the control pilot lines in d.c. electric vehicle charging system.

In addition to the basic communication, the d.c. electric vehicle supply equipment is equipped with digital communication means in order to exchange the control parameters for d.c. charging between the d.c. electric vehicle supply equipment and the vehicle through the high level communication. The following digital communication means are used by the systems defined in Annexes AA and CC:

- a) Control area network (CAN) over dedicated digital communication circuit according to ISO 11898-1; or
- b) Power line communication (PLC) over control pilot circuit.

F-1.3 Charging Control Process and State

F-1.3.1 General

Charging control process of d.c. electric vehicle supply equipments consists of the following three stages:

- a) process before the start of charging (initialization): Initialization includes pre-charge if required. Pre-charge is the final stage of initialization.;
- b) process during charging (energy transfer); and
- c) process of shutdown (shutdown).

The d.c. electric vehicle supply equipment and the vehicle synchronize control process with each other. The following signals and information are used for the synchronization:

- a) signals through the pilot wire circuit;
- b) parameters through the digital communication circuit; and
- c) measurement values such as voltage and current level of the d.c. charging circuit through the digital communication circuit.

The d.c. electric vehicle supply equipment and the vehicle preserve specified time constraints and control timings for ensuring smooth charging control and operation.

Charging sequence diagrams are system specific and described in Annex A and Annex B. Digital communication parameters, formats, and other communication requirements are specified in IS 17017 (Part 24).

F-1.3.2 Description of the Process before the Start of Charging (Initialization)

In this process, the vehicle and the d.c. electric vehicle supply equipment exchange their operational limitations and relevant parameters for charging control. Messages, such as the voltage limit, maximum charging current, etc. are also transferred to each other. Circuit voltage is measured for checking whether the batteries and the d.c. electric vehicle supply equipment are connected before the start of charging and whether the batteries and the d.c. electric vehicle supply equipment are disconnected after the end of charging. The d.c. electric vehicle supply equipment is not to proceed with the next stage of charging process unless it verifies the compatibility with the vehicle. After compatibility check, the d.c. electric vehicle supply equipment conducts the insulation check between the d.c. power lines and the enclosures, including vehicle

chassis. The vehicle connector is latched before the insulation check.

F-1.3.3 *Description of the Process During Charging (Energy Transfer)*

In this process, the vehicle continues to send a setting value of charging current or voltage to the d.c. electric vehicle supply equipment throughout charging process. Either of the following two algorithms is taken.

a) CCC

- 1) The vehicle battery can be charged using CCC with the vehicle as master and the d.c. electric vehicle supply equipment as slave;
- 2) The d.c. electric vehicle supply equipment receives the charging current value the vehicle requested (command value), throughout the charging control process;
- 3) The d.c. electric vehicle supply equipment sets the command value as control target, and regulate the d.c. charging current;
- 4) The command value from the vehicle is notified to the d.c. electric vehicle supply equipment at regular intervals according to the system requirements; and
- 5) The d.c. electric vehicle supply equipment regulates the d.c. charging current responding to the change of command value of the vehicle.

b) CVC

- 1) The vehicle battery can be charged using CVC with the vehicle as master and the d.c. electric vehicle supply equipment as slave.;
- 2) The d.c. electric vehicle supply equipment receives the charging voltage value the vehicle requested (command value) throughout the charging process;
- 3) The d.c. electric vehicle supply equipment sets the command value as control target, and regulate the d.c. charging voltage;
- 4) The command value from the vehicle is notified to the d.c. electric vehicle supply equipment at regular intervals according to the system requirements; and
- 5) The d.c. electric vehicle supply equipment regulates the d.c. charging voltage responding to the change of command value of the vehicle.

F-1.3.4 *Description of Process of Normal Shutdown*

After completion of the charging session, the normal shutdown phase allows the d.c. electric vehicle supply equipment to return to the conditions prior to charging. When the vehicle or d.c. electric vehicle supply equipment indicates the end of charging, the d.c. electric vehicle supply equipment reduces the charge current to zero. The vehicle side contactors open at near zero current. The d.c. electric vehicle supply equipment or the vehicle unlatches the vehicle connector only if the voltage at the inlet between DC+ and DC– is less than 60 V d.c. (see 6.3.1.107).

ANNEX G

(Foreword)

COMMITTEE COMPOSITION

Electrotechnology in Mobility Sectional Committee, ETD 51

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